

Documentation for the Canadian historical Snow Water Equivalent dataset (CanSWE) version v.6

0. History of changes

0.1 Changes compared to version v.1

- Use of the official terminology from the World Meteorological Organization (WMO, 2018): “Water Equivalent of Snow Cover” instead of “Snow Water Equivalent”
- Removal of the depreciated quality flags L and Q
- Update of the definition of the quality flag B

0.2 Changes compared to version v.2

- Snow data for snow season 2021 from national, provincial and territorial agencies as well as hydropower companies and their partners have been added.
- Addition of historical snow data from the government of Manitoba over the period 1985-2021
- Addition of historical snow data from research sites across Canada managed by federal and academic research institutions
- A csv version of CanSWE has been added.
- See Section 3 for details on the updates made in version 3.

0.3 Changes compared to version v.3

- Use of updated metadata (latitude, longitude, elevation) for BC snow sites.
- Use of correct dates for NWT snow surveys for snow season 2021.
- Use of updated metadata (latitude, longitude) for some NWT snow surveys
- Addition of historical snow data from two research sites: Marmot Creek and Fortress Mountain
- See Section 4 for details on the updates made in version 4.

0.4 Changes compared to version v.4

- Snow data for snow season 2022 from national, provincial, and territorial agencies as well as hydropower companies and their partners have been added.
- Addition of historical data from automated snow pillows in Yukon
- New stations ID for 5 Manitoba-Hydro stations
- Correction of snow survey data for Hydro Quebec for snow season 2021.
- See Section 5 for details on the updates made in version 5.

0.5 Changes compared to version v.5

- Snow data for snow season 2023 from national, provincial, and territorial agencies as well as hydropower companies and their partners have been added.
- Addition of historical data from automated stations (passive gamma) from Rio Tinto Alcan
- Addition of data from automated stations (passive gamma) from Manitoba Hydro for snow season 2023
- New stations ID for 23 stations from the government of Northwest Territories
- Correction of snow survey data for New Brunswick for snow season 2021 and 2022.
- Correction of undefined elevation for 10 stations
- Correction of erroneous latitude and/or longitude for 7 stations in Alberta
- See Section 6 for details on the updates made in version 6.

1. Description:

This dataset includes manual and automated pan-Canadian observations of Snow Water Equivalent (SWE, or water equivalent of snow cover according to WMO (2018)) collected by national, provincial and territorial agencies as well as hydropower companies and their partners (see list below). Snow depth and derived bulk snow density are also included when available. A code describes the SWE measurement method for each site following World Meteorological Organization (WMO) standards (WMO, 2019). This new dataset supersedes the most recent update of the Canadian Historical Snow Survey (CHSSD) dataset published by Brown et al. (2019) and available at <https://doi.org/10.18164/cf337b6b-9a87-4ffd-a8e5-41e6498b1474>. The creation of CanSWE used the 2019 CHSSD update as a starting point and involved three main steps: (i) correction and cleaning of the 2019 CHSSD update (correction of metadata, removal of duplicates), (ii) update of this cleaned dataset until July 2020 and addition of snow data from new stations and agencies, and (iii) consistent quality control of the final dataset. The final dataset (CanSWE v1) includes over one million SWE measurements from 2607 different locations across Canada over the snow seasons 1928 – 2020 where a snow season is defined as starting August 01 and ending July 31. CanSWE is described in detail in Vionnet et al. (2021). Further updates are carried out on a regular basis. The latest version (CanSWE version 6) includes snow data until July 31, 2023, at 2921 different locations across Canada.

The agencies that contributed data to CanSWE or the 2019 CHSSD update (included in CanSWE) are listed below:

Data Source	Station ID prefix in CanSWE
Yukon Water Resources Branch	YT
Government of Northwest Territories	NWT
Annual “Snow Cover Data” books published from 1955-1985 by the Meteorological Service of Canada	SCD
British Columbia Ministry of Environment	BCE
Alberta Environment and Parks	ALE
Saskatchewan Water Security Agency	SK
Manitoba Hydro	MB
Ontario Power Generation	OPG
Ontario Ministry of Natural Resources and Forestry	ONR
Hydro Québec	HQ
Government of New Brunswick	ENB
Government of Newfoundland and Labrador	NFL
Rio Tinto Alcan	RTA
Churchill Falls (Labrador) Corporation Ltd	CHURCHILL
Crown-Indigenous Relations and Northern Affairs Canada	INA
Government of Manitoba	MN
Research sites*	UU

*see Sections 3 and 4

Note for Hydro Québec data:



Hydro-Québec’s data are available under the terms of a [Creative Commons Attribution – Non Commercial – Share A Like 4.0 International License](https://creativecommons.org/licenses/by-nc-sa/4.0/).

2. Dataset files:

The following file is included in the dataset directory:

Filename	Description
1. CanSWE-CanEEN_1928-2023_v6.nc	NetCDF version of the final snow dataset. SWE stands for Water Equivalent of snow cover and EEN for Equivalent en Eau de la couverture Neigeuse (in French).
2. CanSWE-CanEEN_1928-2023_v6.zip	Zip compressed file containing the CSV version of the final snow dataset.

A description of the file formats is provided below:

1. Final NetCDF version of updated Canadian historical snow water equivalent dataset
[CanSWE-CanEEN_1928-2023_v6.nc](#)

For each variable in the NetCDF file, specific attributes are used to describe the variable and its units. They are summarized in the Table below.

Description of the variables (dimensions, metadata, data and quality-control flags) present in the NetCDF file containing the CanSWE dataset

Type of variable	Variable name	Description	Dimension	Units
Dimension	station_id	Station identification code	station_id	(-)
	time	Time	time	day
Metadata	lat	Station latitude	station_id	deg. north
	lon	Station longitude	station_id	deg. east
	elevation	Station elevation	station_id	m
	source	Data provider	station_id	(-)
	station_name	Primary station name	station_id	(-)
	station_name_sec	Secondary station name	station_id	(-)
	station_name_ter	Tertiary station name	station_id	(-)
	station_id_sec	Secondary station identification code	station_id	(-)
station_id_ter	Tertiary station identification code	station_id	(-)	
	type_mes	Method of measurement for SWE	station_id	(-)
Data	snw	Water equivalent of snow cover (SWE)	station_id, time	kg m ⁻²
	snd	Snow depth (SD)	station_id, time	m
	den	Snowpack bulk density	station_id, time	kg m ⁻³
Quality-control flag	data_flag_snw	Agency data quality flag for SWE	station_id, time	(-)
	data_flag_snd	Agency data quality flag for SD	station_id, time	(-)
	qc_flag_snw	CanSWE quality control flag for SWE	station_id, time	(-)
	qc_flag_snd	CanSWE quality control flag for SD	station_id, time	(-)

Explanation of the code describing the method of measurement for SWE:

WMO SWE measurement codes (WMO, 2019)

Code	Method of SWE measurement
0	Multi point manual snow survey
1	Single point manual SWE measurement
2	Snow pillow or snow scale
3	Passive gamma
4	Global Navigation Satellite System/ Global Positioning System methods
5	Cosmic ray attenuation
6	Time domain reflectometry

Explanation of agency data flags: These flags for SWE and SD summarize the data flags from the various agencies into a single set of standard values and definitions.

Agency data flags used in CanSWE

Data flag	Definition
A	Sampling problems
B	Manual snow survey conducted outside the nominal sampling period
C	Combination of A and B
E	Estimate
G	Measurement location >1 km from station coordinates. This flag is specific to manual snow survey data provided by the Saskatchewan Water Security Agency beginning in 2011.
M	Missing
P	Patches
R	Revised data
T	Trace
Y	Precise sampling date not available - NWT set to 1 April. MN within 1 week of reported date.

Explanation of quality control (QC) flags:

QC flags used in CanSWE

QC flag	Definition
H	SD > 3 m (>8 m west of -113° longitude). SD set to <i>NaN</i>
M	Data masked (set to <i>NaN</i>) in a previous CHSSD update
V	Automatic SD-SWE measurement identified as outlier using robust Mahalanobis distance. SD and SWE set to <i>NaN</i>
W	SWE > 3000 kg m ⁻² (>8000 kg m ⁻² west of -113° longitude). SWE set to <i>NaN</i>
D	Derived bulk snow density failed 25 - 700 kg m ⁻³ threshold. SD, SWE and derived bulk snow density set to <i>NaN</i>

2. Zip archive containing the latest version of CanSWE in csv format

[CanSWE-CanEEN_1928-2023_v6.zip](#)

The file in csv format contains the same variables as in the Netcdf file (see above). The meaning of each column is given in the header of the csv. Each line of the csv file contains the information for a given date and a given station. Only dates with a valid SWE or a valid SD are kept in the csv file.

3. CanSWE version 3

CanSWE versions 1 and 2 are described in detail in Vionnet et al (ESSD, 2021). This section provides a summary of the updates for CanSWE v3.

Agencies that provided snow measurements for CanSWE v3. The table makes the distinction between manual and automatic snow measurement stations. Updated stations correspond to stations already present in CanSWE v2 for which data for snow season 2021 have been added whereas new stations were not present in CanSWE v2. See the next table for more details on the research sites.

Agency	Manual stations		Automatic stations	
	Updated	New	Updated	New
Yukon Water Resources Branch	58	0	0	0
Government of Northwest Territories	63	1	0	0

Meteorological Service of Canada (ECCC)	10	0	0	0
British Columbia Ministry of Environment	162	0	86	5
Alberta Environment and Parks	108	0	14	0
Saskatchewan Water Security Agency	98	0	0	0
Manitoba Hydro	22	1	0	0
Ontario Power Generation	34	0	0	0
Ontario Ministry of Natural Resources and Forestry	234	7	0	0
Hydro Québec	43	0	58	22
Government of New Brunswick	42	0	0	0
Government of Newfoundland and Labrador	0	0	4	0
Government of Manitoba	0	163	0	0
Research sites	0	27	0	0
Total	874	199	162	27

Quality control

The quality control procedures described in Vionnet et al. (2021) have been applied. In particular, the outlier detection using the robust Mahalanobis distance has been applied over the full historical archive of each automatic station so that SWE and SD data over the period 1928-2020 have been revised. Among the 192 automatic stations present in CanSWE v2, 47 of them had their data revised over the period 1928-2020. For these stations, the proportion of modified records relative to the total length of the record for each station is on average 0.40 % (0.01, 0.05, 0.21, 0.61, 0.99 %, for the 5, 25, 50, 75 and 95 percentiles, respectively).

Research Sites

Data from the sites listed below were added to CanSWE v3. New unique station IDs were assigned with the prefix UU. Because research sites are often maintained and operated by numerous institutions and this varies over time, *source* for all research sites was set to *research site*. Specific research groups responsible for the various sites are listed below.

Research sites added to CanSWE v3.

Location	Time	Sampler	Research group(s)	Data access	Accompanying manuscript
Baker Creek, NWT	2004 – 2016	ESC-30	Environment Climate Change Canada and partners	Spence C, Hedstrom N. (2018) doi:10.20383/101.026	Spence C, Hedstrom N. (2018) ESSD https://doi.org/10.5194/e-ssd-10-1753-2018
Bratt's Lake Research Station, SK	2002 – 2005	ESC-30	Environment Climate Change Canada and partners	Craig D. Smith (craig.smith@ec.gc.ca)	
Caribou Creek Research Station, SK	2013 – 2017	ESC-30	Environment Climate Change Canada and partners	https://donnees.ec.gc.ca/data/climate/scientificknowledge/saskatchewan-solid-precipitation-inter-comparison-experiment-spice-data/	Smith et al. 2019 ESSD https://doi.org/10.5194/e-ssd-11-1337-2019
Duck Lake, SK	2014 – 2018	ESC-30	Environment Climate Change Canada and partners	Craig D. Smith (craig.smith@ec.gc.ca)	
Lake O'Hara/Opabin, AB	2006 – 2017	Federal sampler, Snowpits in 2007	Changing Cold Regions Network (CCRN)	He, J. and Hayashi, M. 2018 https://doi.org/10.20383/101.035	He, J. and Hayashi, M. 2019 ESSD https://doi.org/10.5194/e-ssd-11-111-2019

St Denis National Wildlife Area, SK	1994 – 2017	ESC-30	University of Saskatchewan, National Hydrology Research Centre, ECCC	Bam et al. 2018 https://doi.org/10.20383/101.0115	Bam et al. 2019 https://doi.org/10.5194/essd-11-553-2019
Swift Current Research and development Centre, SK	1965 – 2011	ESC-30	Agriculture and Agrifoods Canada (until 2011)	DEM (ECCC) - Coles et al., 2018 https://doi.org/10.20383/101.0117 SWE data McConkey and Thiagarajan, 2018: https://open.canada.ca/data/en/dataset/b22cd297-cdb4-4d76-9f79-cc1c16d0e9e7	Coles et al. 2019 https://doi.org/10.5194/essd-11-1375-2019
Wolf Creek YT	1993 – 2014	Mt Rose	Environment Yukon, University of Saskatchewan, McMaster University with support from GWF	Rasouli et al. 2018 https://doi.org/10.20383/101.0113	Rasouli et al. 2019 https://doi.org/10.5194/essd-11-89-2019

4. CanSWE version 4

This section provides a summary of the updates for CanSWE v4.

Updated BC metadata

The BC Ministry of Environment carried out an extensive review of their manual snow survey and automatic snow pillows metadata (lat, lon, elevation). The new metadata are used in CanSWE v4. The locations (latitude and/or longitude) of 217 stations were modified (55 snow pillows, 162 manual snow surveys). The distribution of the distances (in km) between the old and the new locations is as follows: 0.03, 0.2, 0.5, 0.8, 1.3, 5.7 and 65 km for the 1, 5, 25, 50, 75, 95 and 99 percentiles, respectively. The elevation was modified for 8 stations (all manual snow surveys).

Accurate dates for NWT snow data for snow season 2021 and updated metadata.

In CanSWE v3, the dates for the NWT manual snow surveys for snow season 2021 were not available. April 1st, 2021, was used as the default date. The precise sampling dates are now included in CanSWE v4. The locations (latitude and longitude) of 24 snow survey stations in NWT have also been updated in CanSWE v4. The distribution of the distances between the old and the new locations (in km) is as follows: 0.2, 0.5, 1.1, 4.2 and 45 km for the 5, 25, 50, 75 and 95 percentiles, respectively.

Research Sites

Data for Fortress Mountain and Marmot Creek research sites were added in v4 following the methods outlined in v3 Research Sites.

Research sites added to CanSWE v4.

Location	Time	Sampler	Research group(s)	Data access	Accompanying manuscript
Marmot Creek Research Basin, AB	2008 – 2021	ESC-30 (shallow snowpacks) & Mt. Rose (deeper snowpacks)	Canadian Rockies Hydrological Observatory	Fang et al. 2018 https://doi.org/10.20383/101.09 Updated to 2021 by Centre for Hydrology, University of Saskatchewan (john.pomeroy@usask.ca)	Fang et al. (2019) ESSD https://doi.org/10.5194/essd-11-111-2019 , 2019

Fortress Mountain Research Site, AB	2014 – 2021	ESC-30 (shallow snowpacks) & Mt. Rose (deeper snowpacks)	Canadian Rockies Hydrological Observatory	John Pomeroy (john.pomeroy@usask.ca) Centre for Hydrology, University of Saskatchewan	
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5. CanSWE version 5

This section provides a summary of the updates for CanSWE v5.

Agencies that provided snow measurements for CanSWE v5. The table makes the distinction between manual and automatic snow measurement stations. *Updated* stations correspond to stations already present in CanSWE v4 for which data for snow season 2022 have been added whereas *new* stations were not present in CanSWE v4.

Agency	Manual stations		Automatic stations	
	Updated	New	Updated	New
Yukon Water Resources Branch	58	0	0	7
Government of Northwest Territories	57	1	0	0
Meteorological Service of Canada (ECCC)	9	0	0	0
British Columbia Ministry of Environment	140	2	89	5
Alberta Environment and Parks	107	0	13	1
Saskatchewan Water Security Agency	104	7	0	0
Manitoba Hydro	27	1	0	0
Ontario Power Generation	35	0	0	0
Ontario Ministry of Natural Resources and Forestry	238	8	0	0
Hydro Québec	21	0	76	8
Government of New Brunswick	41	0	0	0
Government of Newfoundland and Labrador	0	0	4	0
Government of Manitoba	126	1	0	0
Total	963	20	184	21

Correction of manual snow data from Hydro Quebec for snow season 2021

An error has been identified in the data processing of the HQ manual snow data for snow season 2021. Snow depth data were not correctly extracted from the HQ archive. This error has been fixed in CanSWEv5 for snow season 2021 and the QC has been reapplied.

Change of ID for Manitoba-Hydro stations

The IDs of 5 Manitoba Hydro stations has been adjusted to reflect their official IDs: ‘MB-NHA#####’ becomes ‘MB_05UB005’, ‘MB-TPA#####’ becomes ‘MB-05KK713’, ‘MB-TA#####’ becomes ‘MB-TA’, ‘MB-CLA#####’ becomes ‘MB-CLA’, ‘MB-TSC#####’ becomes ‘MB-TSC’ and ‘MB-JA#####’ becomes ‘MB-05UD706’.

6. CanSWE version 6

This section provides a summary of the updates for CanSWE v5.

Agencies that provided snow measurements for CanSWE v6. The table makes the distinction between manual and automatic snow measurement stations. *Updated* stations correspond to stations already present in CanSWE v5 for which data for snow season 2022 have been added whereas *new* stations were not present in CanSWE v5.

Agency	Manual stations		Automatic stations	
	Updated	New	Updated	New
Yukon Water Resources Branch	56	0	5	1
Government of Northwest Territories	50	3	0	0
Meteorological Service of Canada (ECCC)	9	0	0	0
British Columbia Ministry of Environment	138	0	96	6
Alberta Environment and Parks	109	0	15	0
Saskatchewan Water Security Agency	117	1	0	0
Manitoba Hydro	19	0	0	6
Ontario Power Generation	36	0	0	0
Ontario Ministry of Natural Resources and Forestry	248	0	0	0
Hydro Québec	7	0	89	2
Rio Tinto Alcan	0	0	0	14
Government of New Brunswick	41	0	0	0
Government of Newfoundland and Labrador	0	0	3	0
Government of Manitoba	118	0	0	0
Total	948	4	208	29

Correction of manual snow data from New Brunswick for snow seasons 2021 and 2022

An error in the units of snow depth has been identified in the data processing of the NB manual snow data for snow seasons 2021 and 2022. This error led to erroneous QC checks. This error has been fixed in CanSWEv6 for snow seasons 2021 and 2022 and the QC has been reapplied.

Correction of undefined elevation for 10 stations

Undefined elevations (set to NaN) have been reported for 10 stations in CanSWEv5 (and earlier versions). The elevation of each station has been extracted from a reference DEM at the location of the station as described in Vionnet et al. (2021) and added to CanSWEv6. The following stations are concerned: 'INA-07QB01', 'SCD-ON077', 'SCD-SK001', 'SCD-SK008', 'SCD-SK051', 'SCD-SK058', 'SCD-SK071', 'SCD-SK092', 'SCD-SK150', 'INA-10TA01'.

Correction of erroneous locations for 7 stations

Errors in latitude and/or longitude have been reported for several stations in Alberta. These errors have been corrected using the corresponding provincial database. The following stations are concerned: 'ALE-14A12S', 'ALE-14A12', 'ALE-05AA817', 'ALE-07BB811', 'ALE-05AA809', 'ALE-05DB802' and 'ALE-05DD805'.

Change of ID for NWT stations

The IDs of 23 NWT stations have been adjusted to reflect their official IDs in the NWT database. These stations are (oldID:NewID): 'NWT-042': '10FC-SC02', 'NWT-043': '07OB-SC04', 'NWT-047': '10FB-SC02', 'NWT-001': '07PB-SC01', 'NWT-049': '07OB-SC01', 'NWT-054': '10FB-SC04', 'NWT-059': '07OB-SC05', 'NWT-020': '07QD-SC06', 'NWT-046': '10ED-SC06', 'NWT-052': '10FB-SC03', 'NWT-055': '10GD-SC01', 'NWT-056': '10GC-SC02', 'NWT-060': '10FA-SC02', 'NWT-061': '10HA-SC03', 'NWT-062': '10NB-SC01', 'NWT-

063': '10JD-SC01', 'NWT-064': '10LB-SC03', 'NWT-065': '10KA-SC03', 'NWT-066': '10HC-SC02', 'NWT-069': '10MC-SC01', 'NWT-070': '10MC-SC05', 'NWT-071': '10MC-SC04', 'NWT-041': '10FC-SC01'

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Last update: Vincent Vionnet (vincent.vionnet@ec.gc.ca), Colleen Mortimer (colleen.mortimer@ec.gc.ca), 18 March 2024

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