

# Documentation for the creation of the Canadian historical Snow Water Equivalent dataset (CanSWE)

## 1. Description:

This dataset includes manual and automated pan-Canadian observations of Snow Water Equivalent (SWE) 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 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).

The agencies that contributed data to CanSWE and 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

## 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_1928-2020_v1.nc	NetCDF version of the final snow dataset. SWE stands for Snow Water Equivalent and EEN for Equivalent en Eau de la Neige (in French).

A description of the file formats is provided below:

1. Final NetCDF version of updated Canadian historical snow water equivalent dataset  
[CanSWE-CanEEN\\_1928-2020\\_v1.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	(-)
Data	station_id_ter	Tertiary station identification code	station_id	(-)
	type_mes	Method of measurement for SWE	station_id	(-)
	snw	Snow water equivalent (SWE)	station_id, time	kg m <sup>-2</sup>
Data	snd	Snow depth (SD)	station_id, time	m
	den	Snowpack bulk density	station_id, time	kg m <sup>-3</sup>
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	Early or late sampling
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.
L	8AM measurement not available. Flag is specific to snow pillow data provided by British Columbia Ministry of Environment.
M	Missing
P	Patches
Q	8AM measurement available after L code. Flag is specific to snow pillow data provided by British Columbia Ministry of Environment.
R	Revised data
T	Trace
Y	Precise sampling date not available - set to April 1 <sup>st</sup> . Flag is specific to manual snow survey data provided by the Government of the Northwest Territories.

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 <sup>-2</sup> (>8000 kg m <sup>-2</sup> west of -113° longitude). SWE set to <i>NaN</i>
D	Derived bulk snow density failed 25 - 700 kg m <sup>-3</sup> threshold. SD, SWE and derived bulk snow density set to <i>NaN</i>

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## References:

Brown, R. D., Fang, B., and Mudryk, L.: Update of Canadian historical snow survey data and analysis of snow water equivalent trends, 1967–2016. *Atmos. Ocean*, 57, 149–156, <https://doi.org/10.1080/07055900.2019.1598843>, 2019

Vionnet, V., Mortimer, C., Brady, M., Arnal, L. and Brown, R.: Canadian historical Snow Water Equivalent dataset (CanSWE, 1928-2020), submitted to Earth System Science Data, May 2021

WMO (World Meteorological Organization): Global Cryosphere Watch: Improvements in the international reporting of Snow Depth, WIGOS Newsletter, 5, 3-4, <https://community.wmo.int/wigos-newsletters-archive>, 2019