

Documentation for the Canadian historical Snow Water Equivalent dataset (CanSWE) version v.3.

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 has 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.

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 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). CanSWE version 3 includes snow data until July 31 2021.

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 site* | UU |

*see Section 3

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_1928-2021_v3.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_1928-2021_v3.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_1928-2021_v3.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_1928-2021_v3.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 |

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Last update: Vincent Vionnet (vincent.vionnet@ec.gc.ca), Colleen Mortimer (colleen.mortimer@ec.gc.ca), January 21, 2022

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