PROMICE and GC-Net Automatic Weather Station Data

Data available at https://promice.dk, on the GEUS dataverse and https://thredds.geus.dk

Contact: aws_support@geus.dk

Table of Contents

Terms of Use

PROMICE and GC-Net data can be obtained through PROMICE at no charge and without any warranty under the CC-BY-4.0 license, as long as credit is given to the original data.

When used in scientific publications, please include the following:

- In the **acknowledgements**: "Data from the Programme for Monitoring of the Greenland Ice Sheet (PROMICE) are provided by the Geological Survey of Denmark and Greenland (GEUS) at http://www.promice.dk. ZAC, LYN, FRE and NUK_K stations are financially supported by the Glaciobasis programme as part of the Greenland Ecosystem Monitoring project. The NUK_K station is serviced by Asiaq Greenland Survey. The WEG stations are paid for and maintained by Jakob Abermann at the Department of Geography and Regional Science of the University of Graz. The RED_Lv3 station is financed and maintained by Rainer Prinz at the Department of Atmospheric and Cryospheric Sciences of the University of Innsbruck. The SER_B station is paid for and serviced by Anders Bjørk at the Department of Geosciences and Natural Resource Management of the University of Copenhagen."
- A **reference to the dataset paper**: Fausto, R. S., et al. 2021: "Programme for Monitoring of the Greenland Ice Sheet (PROMICE) automatic weather station data", *Earth Syst. Sci. Data*, 13, 3819–3845, https://doi.org/10.5194/essd-13-3819-2021.
- A **reference to the dataset** itself: How, P. et al.: PROMICE and GC-Net automated weather station data in Greenland", *GEUS Dataverse*, https://doi.org/10.22008/FK2/IW73UU.

If your use relies on the historical GC-Net data add:

- A **reference to the historical dataset reprocessing**:

Vandecrux, B., et al. 2023: "The historical Greenland Climate Network (GC-Net) curated and augmented level-1 dataset", *Earth Syst. Sci. Data*, 15, 5467–5489, https://doi.org/10.5194/essd-15-5467-2023

If your use relies on the pypromice processing scripts add:

- A **reference to the software paper:** How, P. et al. 2023: "pypromice: A Python package for processing automated weather station data", *Journal of Open Source Software*, 8(86), 5298, https://doi.org/10.21105/joss.05298

If the data are crucial to your use, we recommend to inform a member of the PROMICE team at GEUS to get a data quality assessment of the variable, site or period of interest.

A Question? Spotted an Issue?

To raise issues regarding our processing, please add an issue here: https://github.com/GEUS-Glaciology-and-Climate/pypromice/issues.

To raise issues regarding our data, please add an issue here: https://github.com/GEUS-Glaciology-and-Climate/PROMICE-AWS-data-issues.

2024 Major Updates

Metadata folder

All metadata files needed to understand the Automatic Weather Station (AWS) data: - **AWS_data_readme.pdf**: This walkthrough guide of the data - **AWS_sites_metadata.csv**: CSV file giving for each site information such as the list of stations that composes it, installation date/coordinates, last valid date/coordinates - **AWS_variables.csv**: list of variables available with basic information - **AWS_stations_metadata.csv** (only on https://thredds.geus.dk): CSV file giving for each station information such as location type, installation date/coordinates, last valid date/coordinates

Terminology

Station vs site

We distinguish between **"station"** and **"site"**, where **station** is one specific AWS and **site** is a location that may encompass data from more than one AWS. The difference between station and site is as follows: - The term **"station"** refers to a coherent AWS installation. A given station can sometimes be upgraded (instrument, logger changed), or relocated. Major changes trigger the update of a station name (called station_id in the datafile attributes). For example,**stations** QAS_U and QAS_Uv3 have different instruments and logger programs, and **stations** NASA-SE and NSE are from two different projects and have different instruments (see below for the merging of historical data). In addition, nearby stations can be active simultaneously, producing redundant observations. - The term **"sites"** refers to locations of radius less than 3-4 km, where one or more stations are or have been active. For convenience, the name of one of the stations active at a site is used as site name (called site_id in the datafile attributes). For instance, the **site** QAS_U contains data from **stations** QAS_U and QAS_Uv3, and the **site** SDM contains data from **stations** South Dome (from historical GC-Net era) and SDM. Table 1 contains the full list of sites.

On the GEUS dataverse, only the merged "site" data is available. On https://thredds.geus.dk both the final "site" data and a simpler version of the "station" data is available.

Level 2 Station vs Level 3 Site datasets

On https://thredds.geus.dk, the **Level 2 Station** dataset contains the simplest level of processed data from individual stations, with unit conversions, calibrations, manual flagging and fixing, and instrument corrections applied. The data are the hourly values, updated with transmission every hour. This data type does not contain the variables marked as "derived" in Table 2 below.

Both on https://thredds.geus.dk and on the GEUS dataverse, the **Level 3 Site dataset** is our go-to dataset. It contains the best available data, including historical data, for each site (see Table 1 below). It also contains, on top of the level 2 processing, the derivation of additional variables (see Table 2 below). The data are available on hourly, daily and monthly resolutions.

rh_*_cor are renamed to rh_*_wrt_ice_or_water

Relative humidity is the ratio between the water vapor pressure and the saturation vapor pressure over a given surface. According to the WMO standard, relative humidities should be given with respect to saturation over water, therefore the variables `rh_u`, `rh_l` and `rh_i` have always been given with respect to saturation over water. However, on ice sheets and when studying the interaction of water vapor with snow and ice, the relative humidities need to be adjusted to be relative to saturation over ice during subfreezing conditions. Values relative to saturation over water still need to be used when temperatures are above freezing.

These relative humidity values, adjusted during subfreezing conditions, were previously available as `rh_u_cor`, `rh_l_cor` and `rh_i_cor` but to avoid confusion we have renamed those variables to `rh_u_wrt_ice_or_water`, `rh_l_wrt_ice_or_water` and `rh_i_wrt_ice_or_water`.

File format

Within each data folder there will be either **csv** and **netcdf** folders containing datafile in the corresponding format. Netcdf files contain many informative attributes and should be self-explanatory and CF-compliant.

Temporal averaging

Within the **csv** and **netcdf** folders, subfolders contain data at **hourly**, **daily** and **monthly** resolution (only hourly for the level 2 data). **Note that the timestamp of the hourly averages indicate the start of the averaged hour.** The averaging process is adapted for each variable (e.g. wind direction or relative humidity need a different averaging). Ten-minute data are collected from the AWS every summer and can be acquired by contacting aws_support@geus.dk.

Merging of data from different AWS into a site-based dataset

Starting in 2021, GEUS has taken over the Greenland Climate Network (GC-Net) programme (see here) and installed/upgraded AWS at the historical GC-Net sites. The GEUS-based GC-Net team has revisited the historical GC-Net AWS data (Vandecrux et al., 2023; Steffen et al., 2022), discarded erroneous measurements and adjusted, when possible, the data to the highest quality standards. This was done so that the historical data could eventually be merged with the data collected by the GEUS GC-Net stations. We refer to the data that pre-dates the GEUS takeover as "historical data". Concurrently, new PROMICE stations have been installed at most PROMICE sites. They were first referred to as "v3" stations, but now that the older "v2" stations are decommissioned and the v3 stations carry the monitoring forward, this version distinction has become unnecessary and multiple stations can be grouped under a single site-specific dataset.

In the updated PROMICE/GC-Net dataset, the distributed files are site-specific. The list of the 51 sites and the names of distinct stations that are currently grouped under each site is given in Table 1.

Gap-free and smoothed coordinates

The coordinates of the GEUS stations are traditionally measured by a GNSS antenna. Unfortunately, these measurements can sometimes fail or record erroneous coordinates. In this 2024 update, the measured coordinates (`gps_lat`, `gps_lon`, `gps_alt`) have been cleaned of most erroneous measurements, and are complemented by three new variables in the Level 3 data product: `lat`, `lon` and `alt`, which give a time-dependent, gap-free and smoothed estimation of the station. This is especially relevant for sites where GNSS antennas were failing for long periods (e.g. SCO_L, SCO_U) or for GC-Net sites where historical stations have been moving over distances up to 4-5 km since their initiation in the 1990s. Note that the time-dependent estimation of the coordinates for the historical GC-Net sites (before 2021) are not measured continuously but interpolated between a limited number of coordinates taken with handheld GPS during maintenance.

Surface height estimation from multiple sensors

The surface height is measured by several instruments. In the 2024 update, a new Level 3 variable `z_surf_combined` summarizes the information from multiple sensors to describe the height of the surface in a continuous series, unless for periods where all surface-ranging instruments are failing. `z_surf_combined` is also used to estimate the time-dependent depth of the thermistors that are continuously measuring the ice or firn temperature (described in the next section). It is an operational implementation of methods previously used punctually for scientific publications (Vandecrux et al., 2024).

At the accumulation sites, the height of the booms are measured by two sonic rangers. The height of the surface can easily be calculated from these two readings and removing instrument height jumps caused by station maintenance or raising of the mast. Once the measurements from the two sonic rangers are converted into heights and the height jumps due to maintenance removed, these two estimations are averaged into`z_surf_combined` to reduce the impact of station tilt, instrumental noise and limited spatial coverage of a single instrument.

PROMICE stations have a sonic ranger installed on the station itself, a sonic ranger installed on a separate stake assembly and a pressure transducer installed at the bottom of a borehole, within a so-called ablation hose (Fausto et al., 2017). The first sonic ranger can only see the accumulation of snow in the winter but cannot see the lowering of the ice surface during ablation season because the station itself lowers with the ice surface. The second sonic ranger can see both the snow accumulating in the winter and the lowering of the ice surface due to melt in the summer. Once the instrument readings are cleaned from erroneous measurements, it is converted from height of the instrument above the surface to a surface height, from which the visible jumps due to stake assembly maintenance are removed. The pressure transducer only records the lowering of the ice surface during the ablation season and is insensitive to the accumulation of snow in the winter. Accounting for the specificities of each instrument, the following procedure is followed at each station to assemble the three records into a single *z_surf_combined*:

1. A variable describing the ice surface height, `z_ice_surf`, is created from `z_pt_cor`, the depth of pressure transducer. `z_ice_surf` is then adjusted manually every time there is maintenance causing a jump in `z_pt_cor`,so that the ice surface height is continuous.
2. The ice ablation period is defined every year as the period starting, respectively ending, with the first week, respectively last week, where `z_ice_surf` is decreasing. If `z_ice_surf` is missing, then June-August is defined as the ice ablation period.
3. During the ice ablation period, `z_surf_combined` is equal to `z_ice_surf`, meaning taken only from the pressure transducer unless it is missing in which case the height derived from the sonic ranger on stake assempbly is used.
4. At the end of the ice ablation season, the height derived from the two sonic rangers are adjusted automatically to match the ice surface height, `z_ice_surf`. Then both of the sonic rangers can describe the accumulation of snow during the winter and its depletion during spring. During the snow season, `z_surf_combined` is taken as the average between of the two surface heights measured by the sonic rangers.
5. Eventually in the following spring, the surface height will decrease as the snow melts, until it reaches the ice surface at the height it was left at the end of the previous ablation season. From then, the pressure transducer is preferentially used again to describe `z_surf_combined`.

This optimal procedure is adapted depending on the available variables during different times of the year. If all sensors are failing over a given period, then the height of the surface after the gap is set manually according to the general slope of the surface height during the periods with good data. Consequently, **surface height change over data gaps should not be regarded as direct observation**, still the surface height trend over the entire period should be unaffected by the gaps. **All surface heights are given relative to (meaning with zero at) the surface height at the initial station installation.**

From the resulting `z_surf_combined`, the surface height derived from multiple instruments, we re-calculate `z_ice_surf` as the one-year lagging minimum of `z_surf_combined`. This allows `z_ice_surf` to be derived by the pressure transducer or sonic ranger on stake assembly during ablation, while having a constant value during the winter period (instead of the noisy winter measurements from the pressure transducer). Lastly, a `snow_height` variable can be calculated as the difference between `z_surf_combined` and `z_ice_surf`. It is a strictly positive variable describing the height of the snow on top of the ice surface. `z_ice_surf` and `snow_height` are only provided for the ablation sites (Table 1, see *Site type*).

Thermistor depth estimation and 10 m ice or firn temperature calculation

The thermistor strings measure temperature at depth at set intervals (e.g., every 1 m). At ablation sites the thermistor string slowly melts out and surfaces while at accumulation sites the thermistor string is slowly buried. Thus over time the initial depth at installation (noted in the raw data) is no longer the depth of measurement. This has been addressed in the following way:

After we make our best estimation of the surface height, we can then specify the dates and depth of installation of thermistor strings to build a time-dependent depth variable for each thermistor. These depths are provided with the Level 3 data product, and used to discard the recordings from surfaced thermistors which is common at the ablation stations. Once each temperature measurement has a depth tag, we can interpolate the firn/ice temperature at a standard 10 m depth. This standard depth has been used to be able to compare temporally and spatially various subsurface temperatures measurements (Vandecrux et al., 2024).

Table 1: List of sites contained in the PROMICE and GC-Net AWS dataset

Site ID	Stations composing the site	Project	Location type	Site type	Installation date
CEN	CEN2, CEN1, GITS	GC-Net	Ice sheet	Accumulation	1995-06-07
CP1	CP1, CrawfordPoint1	GC-Net	Ice sheet	Accumulation	1995-05-23
DY2	DY2, DYE-2	GC-Net	Ice sheet	Accumulation	1996-05-24
EGP	EGP, EastGRIP	GC-Net	Ice sheet	Accumulation	2014-05-17
FRE	FRE	GlacioBasis	Local glacier	Ablation	2021-07-27
HUM	HUM, Humboldt	GC-Net	Ice sheet	Accumulation	1995-06-22
JAR	JAR_O, JAR, JAR1	GC-Net	Ice sheet	Ablation	1996-06-19
KAN_B	KAN_B	PROMICE	Tundra	Bedrock	2011-04-13
KAN_L	KAN_Lv3, KAN_L	PROMICE	Ice sheet	Ablation	2008-09-01
KAN_M	KAN_M	PROMICE	Ice sheet	Ablation	2008-09-02
KAN_T	KAN_Tv3	PROMICE	Ice sheet	Ablation	2024-05-19
KAN_U	KAN_U	PROMICE	Ice sheet	Accumulation	2009-04-04
KPC_L	KPC_Lv3, KPC_L	PROMICE	Ice sheet	Ablation	2008-07-17
KPC_U	KPC_Uv3, KPC_U	PROMICE	Ice sheet	Ablation	2008-07-17
LYN_L	LYN_L	GlacioBasis	Local glacier	Ablation	2021-09-01
LYN_T	LYN_T	GlacioBasis	Local glacier	Ablation	2021-09-01
MIT	MIT	PROMICE	Local glacier	Ablation	2009-05-04
NAE	NAE, NASA-E	GC-Net	Ice sheet	Accumulation	1997-05-03
NAU	NAU, NASA-U	GC-Net	Ice sheet	Accumulation	1995-05-31
NEM	NEM, NEEM	GC-Net	Ice sheet	Accumulation	2006-03-29
NSE	NSE, NASA-SE	GC-Net	Ice sheet	Accumulation	1998-04-24
NUK_B	NUK_B	PROMICE	Tundra	Bedrock	2023-10-03
NUK_K	NUK_K	GlacioBasis	Local glacier	Ablation	2014-07-28
NUK_L	NUK_L	PROMICE	Ice sheet	Ablation	2007-08-20
NUK_N	NUK_N	PROMICE	Ice sheet	Ablation	2010-07-25
NUK_U	NUK_Uv3, NUK_U	PROMICE	Ice sheet	Ablation	2007-08-20
QAS_A	QAS_A	PROMICE	Ice sheet	Ablation	2012-08-20
QAS_L	QAS_Lv3, QAS_L	PROMICE	Ice sheet	Ablation	2007-08-24
QAS_M	QAS_Mv3, QAS_M	PROMICE	Ice sheet	Ablation	2016-08-11
QAS_U	QAS_Uv3, QAS_U	PROMICE	Ice sheet	Ablation	2008-08-07
RED_L	RED_Lv3	LATTICE	Ice sheet	Ablation	2024-08-11
SCO_L	SCO_Lv3, SCO_L	PROMICE	Ice sheet	Ablation	2008-07-22
SCO_U	SCO_Uv3, SCO_U	PROMICE	Ice sheet	Ablation	2008-07-21
SDL	SDL, Saddle	GC-Net	Ice sheet	Accumulation	1997-04-20
SDM	SDM, SouthDome	GC-Net	Ice sheet	Accumulation	1997-04-23
SER_B	SER_B	Mittivakkat	Tundra	Bedrock	2024-07-14
SWC	SWC_O, SWC, SwissCamp	GC-Net	Ice sheet	Ablation	1990-06-01
TAS_A	TAS_A	PROMICE	Ice sheet	Ablation	2013-08-28
TAS_L	TAS_L	PROMICE	Ice sheet	Ablation	2007-08-23
TAS_U	TAS_U	PROMICE	Ice sheet	Ablation	2008-03-11
THU_L	THU_L	PROMICE	Ice sheet	Ablation	2010-08-09
THU_L2	THU_L2	PROMICE	Ice sheet	Ablation	2022-05-16
THU_U	THU_U2v3, THU_U2, THU_U	PROMICE	Ice sheet	Ablation	2010-08-09
TUN	TUN, Tunu-N	GC-Net	Ice sheet	Accumulation	1996-05-16

Site ID	Stations composing the site	Project	Location type	Site type	Installation date
UPE_L	UPE_L	PROMICE	Ice sheet	Ablation	2009-08-17
UPE_U	UPE_U	PROMICE	Ice sheet	Ablation	2009-08-18
WEG_B	WEG_B	Wegener	Tundra	Bedrock	2022-06-29
WEG_L	WEG_L	Wegener	Ice sheet	Ablation	2023-04-15
ZAC_A	ZAC_A	GlacioBasis	Local glacier	Ablation	2023-04-25
ZAC_L	ZAC_Lv3	GlacioBasis	Local glacier	Ablation	2022-04-20
ZAC_U	ZAC_Uv3	GlacioBasis	Local glacier	Ablation	2022-04-21

Installation and latest coordinates can be found in the metadata/AWS_sites_metadata.csv

---

Table 2: Variables in hourly, daily, and monthly Level 3 data files

Variable Name	Units	Description
`time`	yyyy-mm-dd HH:MM:SS	Time stamp of hourly averages given for the following hour
`p_u`, `p_l`, `p_i`	hPa	Air pressure (upper boom, lower boom, instantaneous)
`t_u`, `t_l`, `t_i`	°C	Air temperature (upper boom, lower boom, instantaneous)
`rh_u`, `rh_l`, `rh_i`	%	Relative humidity (upper boom, lower boom, instantaneous) with regard to water
`rh_u_wrt_ice_or_water`, `rh_l_wrt_ice_or_water`, `rh_i_wrt_ice_or_water`	%	Relative humidity (upper boom, lower boom) – adjusted for saturation over ice in subfreezing conditions
`qh_u`, `qh_l`	%	Specific humidity (upper boom, lower boom)
`wspd_u`, `wspd_l`, `wspd_i`	m s^{-1}	Wind speed (upper boom, lower boom, instantaneous) at height `z_boom_u` + 0.4 m
`wspd_u_x`, `wspd_l_x`, `wspd_i_x`	m s^{-1}	Directional wind speed from direction x (upper boom, lower boom, instantaneous)
`wspd_u_y`, `wspd_l_y`, `wspd_i_y`	m s^{-1}	Directional wind speed from direction y (upper boom, lower boom, instantaneous)
`wdir_u`, `wdir_l`, `wdir_i`	degrees	Wind direction (upper boom, lower boom, instantaneous) at height `z_boom_u` + 0.4 m
`dsr`	W m^{-2}	Downwelling shortwave radiation at height `z_boom_u` + 0.1 m
`dsr_cor`	W m^{-2}	Downwelling shortwave radiation – tilt-corrected from `dsr`
`usr`	W m^{-2}	Upwelling shortwave radiation at height `z_boom_u` + 0.1 m
`usr_cor`	W m^{-2}	Upwelling shortwave radiation – tilt-corrected calculated from `usr`
`dlr`	W m^{-2}	Downwelling longwave radiation at height `z_boom_u` + 0.1 m
`ulr`	W m^{-2}	Upwelling longwave radiation at height `z_boom_u` + 0.1 m
`dlhf_u`, `dlhf_l`	W m^{-2}	Latent heat flux (upper boom, lower boom)
`dshf_u`, `dshf_l`	W m^{-2}	Sensible heat flux (upper boom, lower boom)
`albedo`	-	Albedo. Calculated from `dsr_cor` and `usr_cor`
`cc`	%	Cloud cover. Estimated from `dlr` and `t_u`

Variable Name	Units	Description
t_surf	°C	Surface temperature. Calculated from ulr and dlr, with longwave emissivity set to 0.97
z_boom_u,z_boom_l	m	Boom height (upper boom, lower boom)
z_stake	m	Height of sonic ranger on a stake assembly drilled into the ice
z_pt, z_pt_cor	m	Depth of pressure transducer under the ice surface, corrected for pressure variation and antifreeze height
z_surf_combined	m	Height of surface, combined from multiple surface-sensing instruments
z_ice_surface	m	Height of the ice surface for ablation stations, relative to surface height at installation
snow_height	m	Height of snow on top of glacial ice
t_i_1-11	°C	Subsurface temperature from thermistor measurements 1 to 11
dt_i_1-11	m	Depth of subsurface thermistor measurements corresponding to t_i_1-11
t_i_10m	°C	10-metre subsurface temperature derived from thermistor measurements
precip_u, precip_l	mm	Cumulative liquid precipitation (upper boom, lower boom)
precip_u_cor, precip_l_cor	mm	Corrected cumulative liquid precipitation (upper boom, lower boom)
precip_u_rate, precip_l_rate	mm	Corrected liquid precipitation rate (upper boom, lower boom)
gps_lat	degrees north	Latitude, measured by single-phase GNSS antenna
gps_lon	degrees east	Longitude, measured by single-phase GNSS antenna
gps_alt	m	Altitude above mean sea level, measured by single-phase GNSS antenna
lat	degrees north	Smoothed and interpolated latitude
lon	degrees east	Smoothed and interpolated longitude
alt	m	Smoothed and interpolated altitude above mean sea level (orthometric height)
tilt_x	degrees	Tilt to east
tilt_y	degrees	Tilt to north
rot	degrees	Station rotation from true North (azimuth angle)
batt_v	V	Battery voltage
t_rad	°C	Radiation sensor temperature

Variables with _l are only available at the two-boom stations. For details on calculated/corrected variables, please refer to the pypromice package documentation at https://github.com/GEUS-Glaciology-and-Climate/pypromice.

For more information, please refer to the variables look-up table metadata/AWS_variables.csv provided with this data product.

Table 3: Sensor list

Instrument Type	Manufacturer	Model	Accuracy
Barometer	Campbell Scientific	CS100/Setra 278	±2.0 hPa
	Lufft	WS401-UMB	±0.5 hPa (0...40°C)
Thermometer, aspirated	Rotronic	MP100H-4-1-03-00-10DIN	±0.1 K

Instrument Type	Manufacturer	Model	Accuracy
	Lufft	WS401-UMB	±0.2°C (>-20°C), ±0.5°C (>-30°C)
	Vaisala	HMP155	±(0.226 - 0.0028 × temperature) °C
Hygrometer, aspirated	Rotronic	HygroClip HC2 or HC2-S3	±0.8 %RH
	Lufft	WS401-UMB	±2%
	Vaisala	HMP155	±0.6 %RH (0 … 40 %RH), ±1.0 %RH (40 … 95 %RH)
Anemometer	R.M. Young	05103-5	±0.2 ms^{-1} or 1%
Radiometer	Kipp & Zonen	CNR1 or CNR4	±10%
Sonic Ranger (x2)	Campbell Scientific	SR50A	±1 cm or ±0.4%
Pressure Transducer	Ørum & Jensen	NT1400 or NT1700 (GEUS assembly)	±2.5 cm
Precipitation Gauge	Lufft	WS401-UMB	±2%
Thermistor String	GEUS, GeoPrecision	RS PRO Termistor, 100 kΩ / TNode	±0.9%
Inclinometer	HL Planar/Rion	NS-25/E2 (GEUS assembly) / DCM260B compass system	0.6% / 0.2% (azimuth accuracy: 0.8%)
GPS Antenna	Trimble/Tallysman	SAF5270-G/TW4020	2.5 m (indicative)
Iridium Modem	NAL Research	9602-LP	-
Iridium Antenna	Campbell Scientific	30741	-
Batteries (4×28 Ah)	Panasonic/Nickel Metal Hydride (NiMH)	LC-XC1228P	-
Solar Panel	RS PRO	RS PRO 10W/20W	-

Nota bene

- A note on measurement/transmission intervals: All AWS installations measure all variables (except those by GPS) every 10 minutes and transmit hourly averages. In the processing, values are calculated from raw logger data. Data gaps are filled, making use of transmitted data, where available.
- Unrealistic spikes have been removed from the data by setting upper and lower limits as well as custom filters (see Fausto et al. 2021 and How et al. 2023)
- The most recent values in the data files are calculated from transmitted data and will be updated after the next station visit, improving data quality and coverage.
- Automatic weather stations can topple in strong winds or get covered by winter-accumulated snow, in which cases data quality for most measured variables will be reduced. Erroneous data recorded after/during these events are identified and removed from the data but additional issues may remain and can be reported on our user forum.
- During maintenance visits (in spring or summer) the stations may be moved/leveled. Variables such as coordinates, height of boom or depth of pressure transducer will undergo an easily recognizable shift.

List of Previous Major Changes

Edition 4 (since Oct 2022)

- Workflow migrated from IDL/GDL to Python 3.8 and above, in the pypromice toolbox.
- Two-boom processing incorporated.
- Precipitation correction added.
- Range thresholding values changed for various variables (see the pypromice variables documentation).
- See the changelog file (*AWS_changelog.txt*) for sub-Edition changes.

Edition 3 (2019-2022)

- Lower temperature limits set to -80°C, previously -60°C.
- Relative humidity values exceeding 100% now set to 100%.
- Column `RelativeHumidity_wrtWater` removed.
- Column `SpecificHumidity` included.
- Wind speed values of 0 m/s no longer replaced by -999.
- Wind speed is no longer replaced by -999 for wind directions outside the 1-360 degree range.
- Estimates of the sensible and latent heat fluxes included.
- Pressure transducer depth limit set to 30 m, previously 50 m.
- Daily ablation now calculated after smoothing over 5 hourly values to reduce noise by random measurement error.
- Tilt values now smoothed over 7 values to reduce noise by random measurement error.
- Longwave emissivity of snow and ice changed from 1 to 0.97.
- Surface temperature values exceeding 0°C now set to 0°C.
- Latitude and longitude outputted in decimal degrees instead of degrees and decimal minutes.
- Hourly-average raw logger data shifted by one hour (minor bug fix).

Edition 2 (prior 2019)

- Shortwave radiation values are no longer corrected if it requires albedo extrapolation towards the end of the time series.
- Tilt values only given when actually measured
