PROMICE | GC-NET

Programme for Monitoring of the Greenland Ice Sheet

Readme: PROMICE and GC-Net automatic weather station data

Data available at http://www.promice.dk. Contact: info@promice.dk.

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Terms of use

PROMICE and GC-Net data can be obtained through http://www.promice.dk at no charge and without any warranty under CC-BY-4.0 license, as long as credit (meaning a link or a DOI) is given to the original data.

When used in scientific publications, please include the following:

- In the **acknowledgement**: “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.* They include sites financially supported by the Glaciobasis programme as part of Greenland Ecosystem Monitoring (*https://g-e-m.dk/*), maintained by GEUS (ZAC, LYN, FRE) and by Asiaq Greenland Survey (NUK_K). The WEG stations are paid for and maintained by the University of Graz.”
- A **reference to the dataset paper**: Fausto, R. S., et al.: 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, 2021.
- A **reference to the dataset** itself:How, P., et al., 2022, "PROMICE and GC-Net automated weather station data in Greenland", https://doi.org/10.22008/FK2/IW73UU, GEUS Dataverse

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

- A **reference to the historical dataset reprocessing**:
  Vandecrux, B., et al.: 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 , 2023.

If your use relies on the pypromice processing scripts add:

- How et al.:. 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, 2023

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

New dataset structure

Metadata folder

All metadata files needed to understand the Automatic Weather Station (AWS) data:

- **AWS_data_readme.pdf**
- **AWS_stations_metadata.csv**: CSV file giving for each station such as location type, installation date/coordinates, last valid date/coordinates
- **AWS_sites_metadata.csv**: CSV file giving for each site 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

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): **stations** QAS_U and QAS_Uv3 have different instruments and logger programs, **stations** NASA-SE and NSE are from two different projects and have different instruments (see below for the merging of historical data). 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, the **site** SDM contains data from **stations** South Dome (from historical GC-Net era) and SDM. Table 1 contains the full list of sites.

Level 2 Stations

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. Does not contain any of the *derived variables* listed in Table 2 below.

Level 3 Sites

Contains our processed data from AWS sites with, on top of the level 2 processing, the derivation of additional variables (see Table 2 below) and the merging of all **stations** at a given **site**, including historical GC-Net data (see next section for more details). The data are available on hourly, daily and monthly resolutions.

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 average

Within the **csv** and **netcdf** folders, subfolders contain data at **hourly** – and for the level 3 sites folder, **daily** and **monthly** – resolution. The averaging process is adapted for each variable (e.g. wind direction or relative humidity need a different averaging). 10 minute data are collected from the AWS every summer and can be acquired by contacting info@promice.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[1] and installed upgraded AWS at the historical GC-Net sites. The GEUS-based GC-Net team has revisited the historical GC-Net AWS data[2] 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 some other time can just be noisy. 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

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[1] https://eng.geus.dk/about/news/news-archive/2020/december/geus-takes-over-american-climate-stations-on-the-greenland-ice-sheet

[2] Dataset description: https://doi.org/10.5194/essd-15-5467-2023, Data: https://doi.org/10.22008/FK2/VVXGUT

punctually for scientific publications[3].

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[4] installed at the bottom of a borehole, within a so-called ablation hose. 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 is being 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, or missing, variables during different times of the year. For instance, if pressure z_pt_cor is missing during the ice ablation season then z_ice_surf is derived from the sonic ranger on the stake assembly instead. Many other specific cases are handled in the processing scripts. 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**

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[3] https://doi.org/10.5194/tc-18-609-2024

[4] https://doi.org/10.3189/2012JoG12J075

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 recalculate 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). Last, 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/firn temperature calculation

The thermistor strings measure temperature at depth at set intervals (e.g., every 1m). 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[5].

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[5] https://doi.org/10.5194/tc-18-609-2024

Table 1. List of the sites contained in the "level 3 site" PROMICE and GC-Net AWS dataset.

site_id	stations composing the site	project	location_type	site_type (accumulation / ablation)	Installation				Last valid date	Displacement since installation (km)
					date	latitude	longitude	altitude		
CEN	CEN2 CEN1 GITS	GC-Net	ice sheet	accumulation	1995-06-07	77.1378	-61.0411	1872	2024-08-16	6.9
CP1	CP1 CrawfordPoint1	GC-Net	ice sheet	accumulation	1995-05-23	69.881216	-46.977476	1960	2024-08-16	3.5
DY2	DY2 DYE-2	GC-Net	ice sheet	accumulation	1996-05-24	66.479419	-46.277815	2115	2024-08-16	1.0
EGP	EGP EastGRIP	GC-Net	ice sheet	accumulation	2014-05-17	75.583291	-35.992863	2664	2024-08-16	5.8
FRE	FRE	Glaciobasis	local glacier	ablation	2021-07-27	74.387914	-20.832836	685	2024-08-16	0.0
HUM	HUM Humboldt	GC-Net	ice sheet	accumulation	1995-06-22	78.525542	-56.830847	1974	2024-08-16	0.6
JAR	JAR_O JAR JAR1	GC-Net	ice sheet	ablation	1996-06-19	69.498586	-49.682	932	2024-08-16	2.4
KAN_B	KAN_B	PROMICE	tundra		2011-04-13	67.13	-50.18	350	2024-08-16	0.0
KAN_L	KAN_Lv3 KAN_L	PROMICE	ice sheet	ablation	2008-09-01	67.097324	-49.931817	679	2024-08-16	2.4
KAN_M	KAN_M	PROMICE	ice sheet	ablation	2008-09-02	67.065724	-48.816441	1272	2024-08-16	1.8
KAN_T	KAN_Tv3	PROMICE	ice sheet	ablation	2024-05-19	67.150851	-50.035079	504	2024-08-16	0.0
KAN_U	KAN_U	PROMICE	ice sheet	accumulation	2009-04-04	67.00016	-47.016845	1845	2024-08-16	1.1
KPC_L	KPC_Lv3 KPC_L	PROMICE	ice sheet	ablation	2008-07-17	79.911001	-24.085624	377	2023-01-08	0.5
KPC_U	KPC_Uv3 KPC_U	PROMICE	ice sheet	ablation	2008-07-17	79.833905	-25.17046	867	2023-01-20	0.2
LYN_L	LYN_L	GalcioBasis	local glacier	ablation	2021-09-01	69.318918	-53.543892	537	2024-08-16	0.0
LYN_T	LYN_T	GalcioBasis	local glacier	ablation	2021-09-01	69.304271	-53.590203	940	2024-04-19	0.0
MIT	MIT	PROMICE	local glacier	ablation	2009-05-04	65.692564	-37.825558	465	2023-09-01	0.2
NAE	NAE NASA-E	GC-Net	ice sheet	accumulation	1997-05-03	74.999995	-30.000935	2623	2024-08-16	0.9
NAU	NAU NASA-U	GC-Net	ice sheet	accumulation	1995-05-31	73.842035	-49.492071	2338	2024-08-16	1.7
NEM	NEM NEEM	GC-Net	ice sheet	accumulation	2006-03-29	77.4413	-51.0999	2460	2024-08-16	0.5
NSE	NSE NASA-SE	GC-Net	ice sheet	accumulation	1998-04-24	66.479796	-42.500533	2372	2024-08-16	0.5
NUK_B	NUK_B	PROMICE	tundra	ablation	2023-10-03	64.461443	-50.152741	109	2024-08-16	0.0
NUK_K	NUK_K	PROMICE	local glacier	ablation	2014-07-28	64.162259	-51.358658	714	2024-05-06	0.0
NUK_L	NUK_L	PROMICE	ice sheet	ablation	2007-08-20	64.481722	-49.521593	585	2024-08-16	1.9

NUK_N	NUK_N	PROMICE	ice sheet	ablation	2010-07-25	64.945811	-49.883669	928	2014-07-25	0.1
NUK_U	NUK_Uv3 NUK_U	PROMICE	ice sheet	ablation	2007-08-20	64.498732	-49.258681	1148	2024-08-16	2.0
QAS_A	QAS_A	PROMICE	ice sheet	ablation	2012-08-20	61.245371	-46.733793	1019	2015-08-24	0.3
QAS_L	QAS_Lv3 QAS_L	PROMICE	ice sheet	ablation	2007-08-24	61.024202	-46.872451	281	2024-08-16	2.0
QAS_M	QAS_Mv3 QAS_M	PROMICE	ice sheet	ablation	2016-08-11	61.09988	-46.833018	626	2024-08-16	2.3
QAS_U	QAS_Uv3 QAS_U	PROMICE	ice sheet	ablation	2008-08-07	61.178867	-46.816228	909	2024-08-16	1.0
SCO_L	SCO_Lv3 SCO_L	PROMICE	ice sheet	ablation	2008-07-22	72.229163	-26.816532	474	2024-08-16	1.7
SCO_U	SCO_Uv3 SCO_U	PROMICE	ice sheet	ablation	2008-07-21	72.394385	-27.264289	994	2024-08-16	2.4
SDL	SDL Saddle	GC-Net	ice sheet	accumulation	1997-04-20	65.9999	-44.5026	2451	2024-08-16	0.0
SDM	SDM SouthDome	GC-Net	ice sheet	accumulation	1997-04-23	63.1489	-44.8175	2878	2024-08-16	0.0
SER_B	SER_B	PROMICE	bedrock		2024-07-14	65.679719	-37.91736	31	2024-08-16	0.0
SWC	SWC_O SWC SwissCamp SwissCamp10m	GC-Net	ice sheet	ablation	1990-06-01	69.574212	-49.29431	1155	2024-08-16	6.7
TAS_A	TAS_A	PROMICE	ice sheet	ablation	2013-08-28	65.780899	-38.903294	897	2023-10-09	0.9
TAS_L	TAS_L	PROMICE	ice sheet	ablation	2007-08-23	65.641699	-38.898064	274	2024-08-16	0.3
TAS_U	TAS_U	PROMICE	ice sheet	ablation	2008-03-11	65.70129	-38.865911	575	2015-08-13	0.5
THU_L	THU_L	PROMICE	ice sheet	ablation	2010-08-09	76.39984	-68.265313	577	2024-08-16	0.1
THU_L2	THU_L2	PROMICE	ice sheet	ablation	2022-05-16	76.393024	-68.265009	573	2024-08-16	0.0
THU_U	THU_U2v3 THU_U2 THU_U	PROMICE	ice sheet	ablation	2010-08-09	76.419623	-68.144869	765	2024-08-16	3.5
TUN	TUN Tunu-N	GC-Net	ice sheet	accumulation	1996-05-16	78.015985	-33.988913	2074	2024-08-16	0.9
UPE_L	UPE_L	PROMICE	ice sheet	ablation	2009-08-17	72.893219	-54.295084	229	2024-08-16	0.0
UPE_U	UPE_U	PROMICE	ice sheet	ablation	2009-08-18	72.891274	-53.535554	978	2024-08-16	3.4
UWN	UWN	UWN	not Greenland		2020-04-18	61.682921	7.212515	610	2024-08-16	1.2
WEG_B	WEG_B	Wegener	tundra		2022-06-29	71.141465	-51.222044	13	2024-08-16	0.0
WEG_L	WEG_L	Wegener	ice sheet	ablation	2023-04-15	71.205085	-51.097155	935	2024-08-16	0.1
ZAC_A	ZAC_A	GlacioBasis	local glacier	ablation	2023-04-25	74.647555	-21.652034	1483	2024-06-04	0.0
ZAC_L	ZAC_Lv3	GlacioBasis	local glacier	ablation	2022-04-20	74.624169	-21.374416	628	2024-08-15	0.0
ZAC_U	ZAC_Uv3	GlacioBasis	local glacier	ablation	2022-04-21	74.643398	-21.462629	868	2024-07-28	0.1

Table 2. Variables in hourly, daily and/or monthly data files

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

Variable name	Units	Description
Core measurements, corrected/calculated if necessary		
time	yyyy-mm-dd HH:MM:SS	Time. Time stamp of hourly averages given for 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_cor, rh_l_cor	%	Relative humidity (upper/lower boom) – corrected for saturation over ice in subfreezing conditions
wspd_u, _l, _i	m s-1	Wind speed (upper, lower boom, instantaneous) at height z_boom_u + 0.4 m
wdir_u, _l, _i	degrees	Wind from direction (upper, 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
albedo	-	Albedo. Calculated from dsr_cor and usr_cor
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
t_surf	°C	Surface temperature. Calculated from ulr and dlr. Surface longwave emissivity is set to 0.97
z_boom_u	m	Upper boom height
z_boom_l	m	Lower boom height
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, if possible corrected for pressure variation and height of antifreeze blatter above surface.
t_i_1-11	°C	Subsurface temperature from thermistor measurements 1 to 11. Their depth is derived in d_t_i_1-11.
precip_u	mm	Precipitation (upper boom) (cumulative liquid)
precip_u_cor	mm	Precipitation (upper boom) (cumulative liquid) – corrected
precip_l	mm	Precipitation (lower boom) (cumulative liquid)
precip_l_cor	mm	Precipitation (lower boom) (cumulative liquid) – corrected
gps_lat	degrees	Latitude, measured by single-phase GNSS antenna

	north	
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
Derived variables		
qh_u, qh_l	%	Specific humidity (upper/lower boom). Calculated from rh_*_cor.
cc	%	Cloud cover. Estimated from dlr and t_u
dlhf_u, _l	W m-2	Latent heat flux (upper/lower boom). Calculated using gradients of wind speed and humidity between the surface and measurement height. Aerodynamic surface roughness for momentum is set to 0.001 m
dshf_u, _l	W m-2	Sensible heat flux (upper/lower boom). Calculated using gradients of wind speed and temperature between the surface and measurement height. Aerodynamic surface roughness for momentum is set to 0.001 m
z_surf_combined	m	Height of surface, relative to surface height at installation, combined from multiple surface-sensing instruments.
z_ice_surface	m	Height of the ice surface (excluding seasonal snow on glacial ice), relative to surface height at installation, combined from multiple surface-sensing instruments. For ablation stations only.
snow_height	m	Height of snow on top of glacial ice.
d_t_i_1-11	m	Depth of subsurface temperature measurement (positive downward).
lat	degrees north	Latitude, smoothed and inter/extrapolated from measurements
lon	degrees east	Longitude, smoothed and inter/extrapolated from measurements
alt	m	Altitude above mean sea level, smoothed and inter/extrapolated from measurements
Diagnostic variables		
tilt_x	degrees	Tilt to east. Station may have rotated.
tilt_y	degrees	Tilt to north. Station may have rotated.
rot	degrees	Station rotation from true North. Station may have rotated.
batt_v	V	Battery voltage
fan_dc_u, _l	mA	Fan current (upper/lower boom). Current drawn for ventilation of the temperature and humidity assembly. Normal values exceed 100 mA
freq_vw	Hz	Frequency of vibrating wire in precipitation gauge
t_log	°C	Logger temperature
t_rad	°C	Radiation sensor temperature

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

Table 3. Sensor list

Instruments in italic are only installed on PROMICE v2 stations. They are being replaced by v3 stations.

Instrument type	Manufacturer	Model	Accuracy (unit)
Barometer	Campbell Scientific Lufft	CS100/Setra 278 WS401-UMB	±2.0 (hPa) ±0.5 hPa (0...40°C)
Thermometer, aspirated	Rotronic Lufft Vaisala	MP100H-4-1-03-00-10DIN WS401-UMB HMP155	±0.1 (K) ±0.2°C (>-20°C), ±0.5°C (>-30°C) ±(0.226 - 0.0028 × temperature) °C
Hygrometer, aspirated	Rotronic Lufft Vaisala	HygroClip HC2 or HC2-S3 WS401-UMB HMP155	±0.8 % (RH) ±2% ±0.6 %RH (0 … 40 %RH), ±1.0 %RH (40 … 95 %RH)
Anemometer	R.M. Young	05103-5	±0.2 (m s−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 in GEUS assembly	NT1400 or NT1700	±2.5 (cm)
Precipitation gauge	Lufft	WS401-UMB	±2 % (Res. 0.5 mm, Max. intensity 144 mm/h)
Thermistor string	GEUS GeoPrecision	RS PRO Termistor, 100 kΩ TNode	±0.9 (%) ±0.1 (K)
Inclinometer	HL Planar in GEUS assembly	NS-25/E2	0.6 (%)
GPS antenna	Trimble/Tallysman Iridium	SAF5270-G/TW4020	2.5 (m) indicative
Iridium modem	NAL Research	9602-LP	–
Iridium antenna	Campbell Scientific	30741	–
Batteries (4×28 A h)	Panasonic	LC-XC1228P	–
Solar panel	RS PRO	RS PRO 10 W	–

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.

Nota bene

- Unrealistic spikes have been removed from the data by setting upper and lower limits as well as custom filters (see

Fausto et al. and How et al?)

- 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 major changes

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.

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 4 (since Oct. 2022)

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