ClimateBasis Nuuk Manual

Version 2 – June 2025

This edition of the ClimateBasis Manual

Please note that ClimateBasis procedures are subject to ongoing changes and improvements and therefore, the manual is per definition always under construction/preliminary. If you have questions or comments to this edition, please contact:

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Acknowledgements

This ClimateBasis manual is based on the guidelines and experiences given by scientific managers, fieldworkers and collaborators who have been involved in the ClimateBasis monitoring program throughout the last 18 years.

Project no.: B53

Asiaq Report 2025-05
Kirsty Langley

Contents

1. Introduction

1.1 The ClimateBasis program

The ClimateBasis monitoring programme in Kobbefjord. Nuuk was initiated in 2007. It is a subprogram of the environmental monitoring programme Greenland Ecosystem Monitoring (GEM) and is one out of three ClimateBasis programs in Greenland with sister programs in Zackenberg (NE Greenland) and Qeqertarsuaq (Disko Bay, West Greenland) representing the Low Arctic, the High Arctic and border between the Low and High Arctic, respectively. The program is funded by the Danish Energy Agency, Environmental Protection Agency and the Government of Greenland.

The primary objective of the ClimateBasis monitoring program in Kobbefjord is to establish baseline knowledge on climate and hydrology within a low arctic environment to allow the study of trends and variability of this sensitive and rapidly changing environment.

The ClimateBasis program in Kobbefjord collects, processes and studies climate data by means of two automated weather station (AWS); hydrology data with one automated hydrometric station and 6 diver stations (see below for description of a diver), and an annual snow survey to characterise the snow pack. This manual describes in detail the monitoring sites and the measured parameters.

1.2 ClimateBasis data availability

Data from the ClimateBasis Nuuk monitoring program is freely available through the GEM database https://data.g-e-m.dk/ . Any questions regarding the ClimateBasis Nuuk data can be addressed to Kirsty Langley (kal@asiaq.gl).

All ClimateBasis data are public domain. However, when using ClimateBasis data, the DOI for each dataset must be cited and the following acknowledgement must be included: Data from the Greenland Monitoring Program were provided by Asiaq – Greenland Survey.

All timestamps referred to in the database are in the West Greenlandic Winter Time (WGWT) UTC-3. Note, the current WGWT is UTC-2, but all data remains in the previous WGWT of UTC-3. Selected data from each field season is published in the ‘GEM Annual Report Cards, published by Aarhus University. Prior to 2016 data were published in the ‘GEM Annual Report’.

1.3 Access to Kobbefjord

The Kobbefjord research station is managed by the Greenland Institute for Natural Resources. Details on booking the facilities, use of the huts and safety are included in the site manual, found here: https://g-e-m.dk/gem-localities/nuuk-basic/access

1.4 Equipment and storage

ClimateBasis has a rubber dinghy and small motor for transporting people and equipment across Badesø. Over winter the dinghy is deflated and stored under the kitchen hut. Pump and oars are kept in the storage hut next to the workshop hut. At the start of the season, 2 Asiaq life vests and the small outboard motor should be taken in and kept in the storage hut for use during the season. These should be returned to Asiaq at the end of each season for service.

Note, only 2 people should be in the dinghy at any time. Life vests must always be worn.

Figure 1.1 ClimateBasis shelf in the storage hut in Kobbefjord.

2 Site Descriptions

The climate monitoring program has been steadily developed since the first measurements in 2006 and currently nine locations are included as monitoring sites for climate and hydrology in Kobbefjord, see Figure 2.1

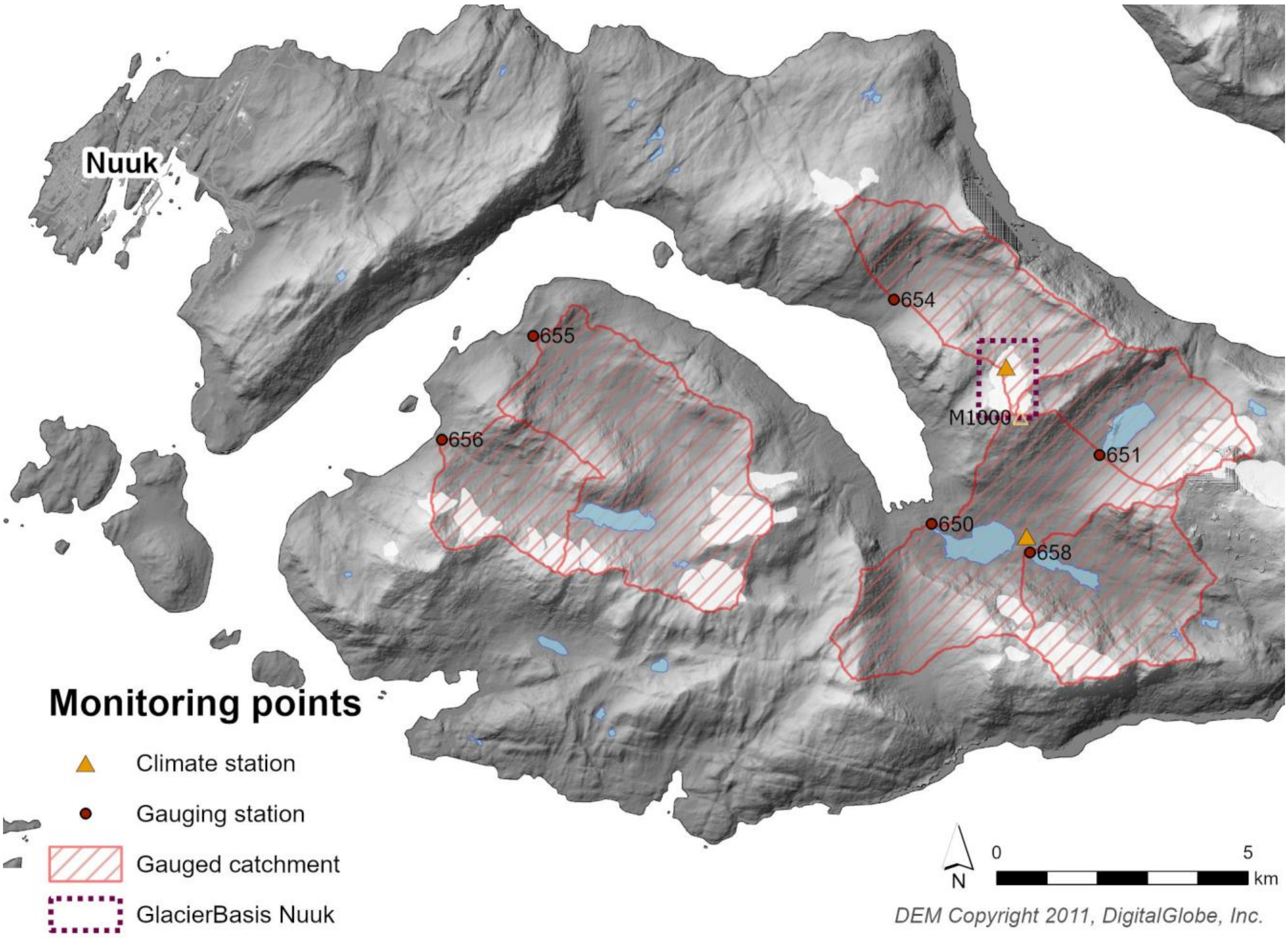

Figure 2.1 Map of ClimateBasic measuring sites in Kobbefjord.

Kobbefjord drainage basin consists of numerous smaller drainage basins. Two climate stations are located on the south-eastern shore of the lake Kangerluarsunnguup Tasia (Badesø) in drainage basin 650, which is the largest drainage basin in Kobbefjord. The hydrological monitoring consists of a permanent hydrometric station located at the outlet of the lake monitoring the 650 catchment. In addition, there are 5 smaller diver stations, two located in sub-catchments of 650, 651 to the NE and 658 to the SE; one located in the catchment 654, fed in part by melt from Qassinguit Sermiat, the glacier monitored by GlacioBasis Nuuk; and two in small catchments, 655 and 656, covering the outer southwest area of the fjord. All stations measure year round, but only the climate stations and the hydrometric station, send data daily to Nuuk via the relay station at M1000.

Table 2.1 gives the geographical location of the ClimateBasic measuring sites. Due to variations in the local morphology it has not been possible to place all discharge measuring cross sections at the same location as the measuring stations.

Station Name	Station Type	Asiaq Station Number	Latitude	Longitude
Kobbefjord Climate 1 and 2	Climate	652 and 653	N64°07'59.9"	W51°20'35.7"
Kobbefjord Climate 1 and 2	Relay	M1000	N64°09'13.2"	W51°21'01.9"
Kobbefjord Hydro 1	Hydrometric	650	N64°07'59.2"	W51°22'50.8"
Kobbefjord Hydro 1	cross section	650	N64°08'04.4"	W51°22'53.2"
Kobbefjord Qassinguaq	Diver	651	N64°09'23.6"	W51°18'42.2"
Kobbefjord Qassinguaq	Diver	651_2	N64°08'07.4"	W51°20'40.9"
Kobbefjord Qassinguaq	cross section	651	N64°08'04.2"	W51°20'54.0"
Kobbefjord Langsø	Diver	658	N64°7'48.6"	W51°20'23.4"
Kobbefjord Oriartorfik	Diver	654	N64°10'18.7"	W51°24'23.8"
Kobbefjord Oriartorfik	cross section	654	N64°10'13.4"	W51°24'26.2"
Kobbefjord Teqqinngalip	Diver	655	N64°09'31.0"	W51°32'54.2"
Kobbefjord Kingigtorssuaq	Diver	656	N64°08'19.4"	W51°34'46.2"

Table 2.1 Positions of ClimateBasic measuring sites. Positions are measured with a handheld gps.

2.1 The Climate Monitoring Stations 652 and 653

Two identical climate stations, 652 and 653, are placed in the same microclimatic environment in the east-west orientated central valley of drainage basin 650. The stations are surrounded by high mountains. The highest mountain in the area is NE of the stations, reaching 1389 m elevation. The mountain south of the station reaches 1157 m and to the NNW of the stations the mountain is 1010 m. On all three, mountains glaciers are present on the northern slopes.

The climate monitoring program utilizes a double mast setup with independent sensors and power supply to give redundant measurements, increasing the robustness of the timeseries. Each climate station consists of a 10m main mast, two 2m masts, one for snow depth and one for radiation sensors, and a precipitation gauge, see, Figure 2.2. All masts were erected around May 14th 2007. The 10 m masts are bolted onto a bedrock exposure, approximately 40 m above mean sea level, surrounded by relatively level terrain. The majority of the radiation sensors are placed on the separate 2 m masts, approximately 40 m east of the main 10m masts. The vegetation underneath the radiation masts is a mixture of salix and empetrum and is 0-20 cm high. The snow depth sensors are placed on the remaining two 2m masts, roughly 20m east of the 10m masts with similar ground conditions as the radiation masts.

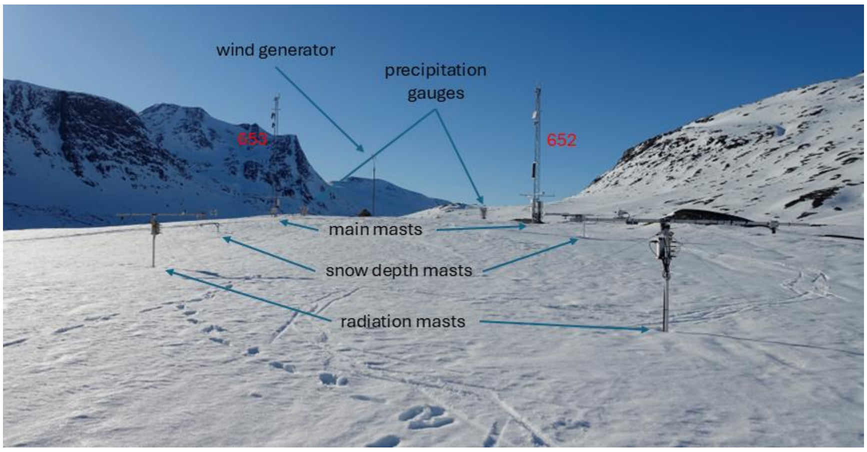

Figure 2.2 An overview of the double climate station 652 and 653.

2.2 Relay Station M1000

The M1000 station is located north of the lake Kangerluarsunnguup Tasia at approximately 1000m elevation. The northern face of this mountain lies Qassinguit Sermiat, the glacier monitored by GlacioBasis Nuuk. M1000 was previously run as a climate station, however, the harsh climate and severe icing / riming that occurs in this location has led to it being used primarily as a relay station for data transmission from the climate and hydrometric stations.

Figure 2.3 M1000 station with a view to the Kobbefjord valley.

2.3 Hydrometric Station 650

The hydrometric station 650 is located on the northern shore of the lake Kangerluarsunnguup Tasia (Badesø) close to the outlet of the lake and approximately 800 m from the fjord 30 m above mean sea level. The station was established May 15th 2007, but measurements have been carried out since June 2006 by the use of divers (see section 2.4). The water level in the lake is measured relative to a reference point on land using survey grade levelling equipment. The reference point is given a height in a relative height system. The drainage area covers 32 km^2 which includes sub-basins 651 and 658. Discharge measurements are made at two cross sections, depending on ice conditions; see Figure 2.4 and Figure 2.5.

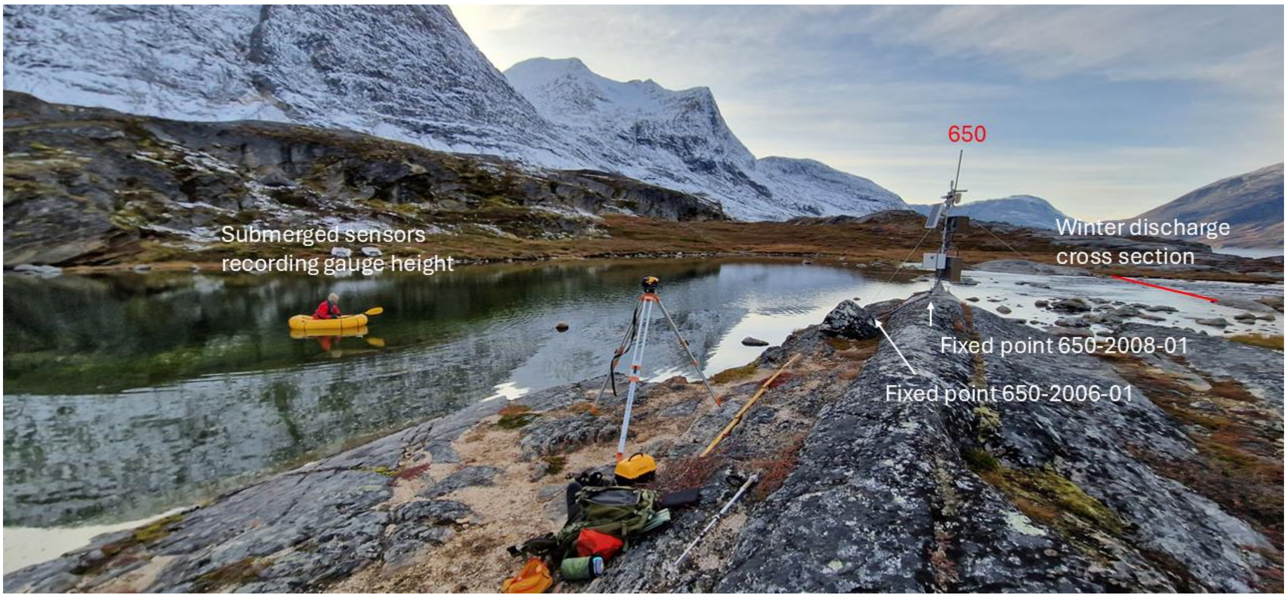

Figure 2.4 650 at the outlet of Kangerluarsunnguup Tasia

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Figure 2.5 650 summer cross section approximately 100 m downstream from the outlet.

2.4 Diver Station Description

A diver station consists of two divers placed in the water and one barodiver placed on land. A diver/barodiver is an independent unit containing a pressure transducer and a temperature sensor as well as a data logger, watch and power supply. The diver records absolute pressure i.e. the pressure due to both water and atmosphere. To obtain the water level the atmospheric pressure measured by the barodiver is subtracted from the diver data.

Divers are deployed both in lakes (650, 651, 658) and rivers (651_2, 654, 655, 656). The divers placed in lakes are attached to a rock with a wire to land. They are submerged deep enough such that they do not freeze in winter. Initially, the river divers were deployed in spring and collected in autumn before the water froze, typically April to October. During the summer period, the divers are placed in a pvc pipe (Figure 2.6). Since 2014 a simple winter setup has been used in which the divers are placed in a small latex bag with anti-freeze surrounding the sensor, allowing year round measurement (Figure 2.7). The water level at the diver stations is measured relative to a reference point on land using survey grade levelling equipment. The reference point is given a height in a relative height system. Repeat measurements lead to an accuracy of better ±5 mm. This is done routinely when sensors are exchanged.

Figure 2.6 Summer set up of river diver station in a PVC pipe. The winter set-up can be seen on the river bed

Figure 2.7 Preparing the river winter diver setup for deployment.

2.4.1 Diver Station 651 and 651_2 Qassinguaq

The station 651 is located in the lake Qassinguaq on the north-western shore about 1 km from the outlet of the lake; see Figure 2.8. The site lies approximately 210 m above sea level. The station was established May 7th 2007 as a hydrometric station (ClimateBasis Manual, 2009) and since 2016 has been operated as a diver station. The drainage area covers 8 km^2 and is a sub-basin of 650. Discharge measurements were made at a preliminary site by the outlet of the lake, but moved to a cross section approximately 70m upstream from the inlet to Kangerluarsunnguup Tasia; see Figure 2.9.

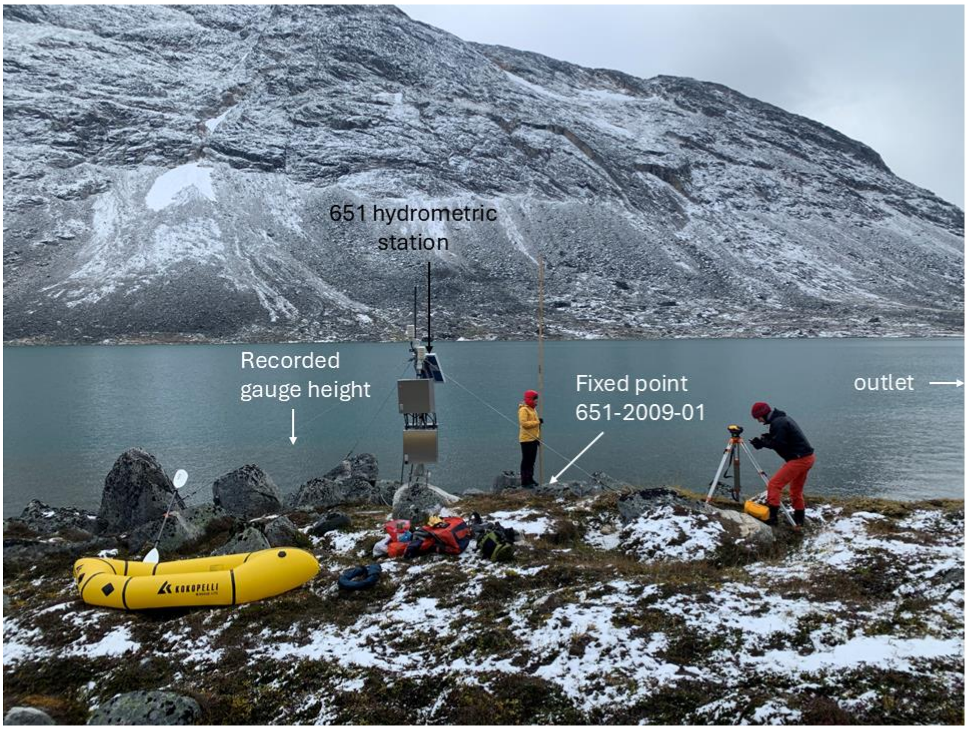


Figure 2.8 651 measuring site

Figure 2.9 651 and 651_2 discharge cross section

The diver station 651_2 is located 300m upstream from the discharge cross section, 370m upstream from the inlet to Kangerluarsunnguup Tasia; see Figure 2.10. The station is at 77 meter above sea level. The measurements at 651_2 started in 2020.

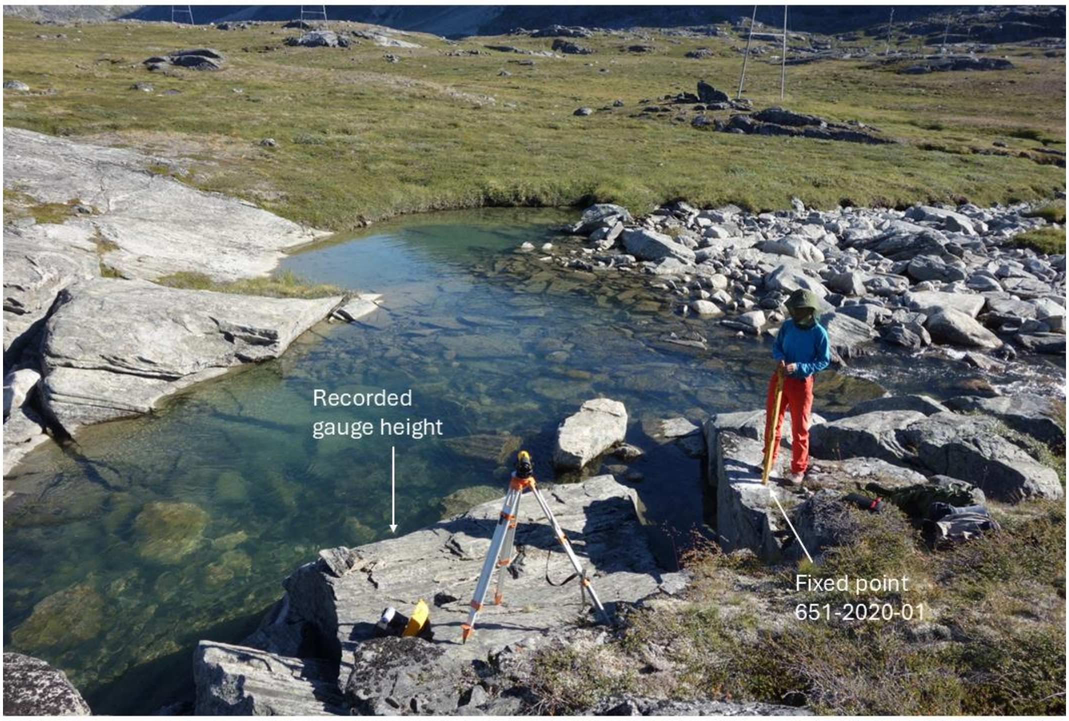


Figure 2.10 651_2 measuring site

2.4.2 Diver Station 658 Langsø

The diver station 658 is located in the lake Langsø, on the north side, approximately 50m from the outlet. The station is at 62m above sea level. The drainage area covers 10 km^2 and is a sub-basin of 650. Discharge measurements are made approximately 50 m downstream of the outlet; see Figure 2.12. The measurements at 658 started in 2014.

Figure 2.11 658 measuring site in the lake Langsø and discharge cross section

2.4.3 Diver Station 654 Oriartorfik

The diver station 654 is located in a rivulet draining the northern part of Kobbefjord. The southern part of the drainage basin includes part of the Qassinnguit Sermiat, monitored by GlacioBasis Nuuk; see Figure 2.1. The divers are placed approximately 1100 m inland from the fjord, 100 m above sea level. The drainage area covers 10 km^2. Discharge measurements are made approximately 100 m downstream of the divers; see Figure 2.12 and Figure 2.13., The measurements at 654 started in 2007.

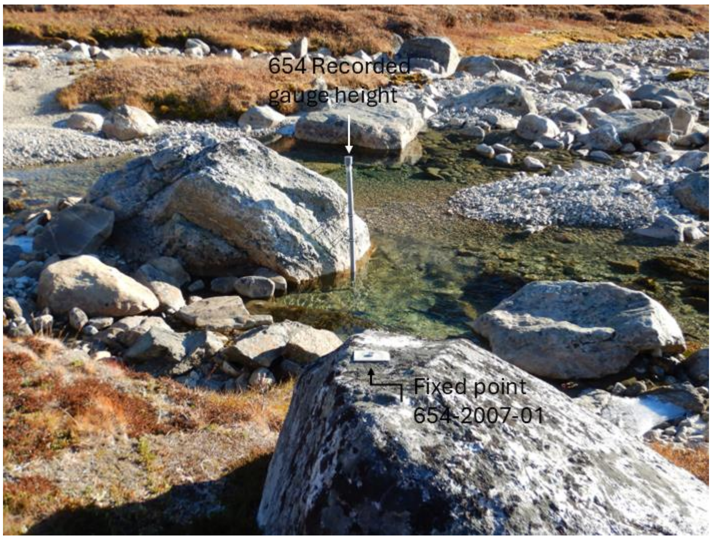


Figure 2.12 654 at Oriartorfik.

Figure 2.13 654 cross section approximately 100 m downstream from the measuring site.

2.4.4 Diver Station 655 Teqqinngalip

The diver station 655 is located in a rivulet draining the southern part of Kobbefjord; see Figure 2.1. The divers are placed approximately 600 m from the fjord, 30 m above sea level. The drainage area covers 18 km^2. Discharge measurements are made approximately 20 m downstream of the divers; see **Figure 2.14 655 at Teqqingalip.**

Figure 2.14 655 at Teqqingalip.

Figure 2.15 655 cross section approximately 20 m downstream from the measuring site.

2.4.5 Diver Station 656 Kingittorssuaq

The diver station 656 is located in a rivulet draining the south-western part of Kobbefjord; see Figure 2.1. The divers are placed approximately 500 m from the fjord, 30 m above sea level. The drainage area covers 6 km^2. Discharge measurements are carried out at a river cross section just upstream of the diver location; see Figure 2.16. The measurements at 656 started in 2008.

Figure 2.16 656 at Kingittorssuaq, both measuring site and cross section.

3 Measured Parameters

3.1 The Climate Stations, C1 and C2

At the climate stations, 652 and 653, 15 different parameters are measured. In Table 3.1 the parameter, current sensor type, sensor height above terrain and specifications are seen with the aggregation method.

parameter	sensor	range	sensitivity	accuracy	valid at
air temperature	Rotronic, HC2A-S3	-50–100 °C	0.1 °C	± 0.1 °C	23 °C
		2 m	30 - sample, ave, min, max		
		10 m	30 - sample, ave, min, max		
relative humidity		0–100 %	0.1 %	± 0.8 %	23 °C
		2 m	30 - sample, ave		
		10 m	30 - sample, ave		
air pressure	Vaisala, PTB110	600–1060 hPa	0.1 hPa	± 0.3 hPa	20 °C
		1.6 m	30 – average		
wind speed	Theodor Friedrichs 4037.1400	0.3–60 ms^{-1}	0.5 ms^{-1}	±0.3 ms^{-1}	>15 ms^{-1}
				± 2 %	<15 ms^{-1}
		2 m	10 – ave, max		
		10 m	10 – ave, max		
	Gill Instruments, Wind Observer 65*	0.01–70 ms^{-1}	0.01 ms^{-1}	± 2%	12 ms^{-1}
		10 m	10 – ave, max		
wind direction		0, 359°	1°	± 2°	12 ms^{-1}
		10 m	10 – ave		
shortwave	Kipp & Zonen, CNR4	0–2000 Wm^{-2}	10-20 $\mu V/W/m^2$	± 5 %	daily
		2 m	5 – ave		
longwave	Kipp & Zonen, CNR4	± 250 Wm^{-2}	5–15 $\mu V/W/m^2$	± 10 %	daily
		2 m	5 – ave		
UV-B	Solar Light, 501A**	0–10 $MEDh^{-1}$		± 5 %	daily
		2 m	5 – ave		
UVS-AB	Kipp & Zonen UVS-AB-T***	0-6 W/m^2	daily		
		2 m	5 – ave		
PAR	Kipp & Zonen, PAR Lite	0–10000 $\mu mol/m^2s$	4–10 $\mu V/\mu mol/m^2s$	± 10 %	
		2 m	5 – ave		
Relative vegetation index	Skye Inst. SKR110	<500 µmol/(s.m2)	100 µmol/(s.m2)	± 3-5 %	
		2 m	5 – ave		
precipitation	Ott, Pluvio²L	0 - 3000 mm/hr	0.01 mmh^{-1}	± 1 %	
			60 – sample		
snow depth	Campbell Scientific, SR50A	0.5–10 m	0.25 mm	± 1 cm or 0.4 %	
		2 m	ave over last 2 of every 60 minutes		

Table 3.1: Parameters measured at climate station 652 and 653. For each parameter, the parts of the table

underlain in blue give the sampling scheme currently in use. For several sensor types, more than one sensor is mounted at different heights, which are given in the first column, whereas the second column gives the sampling type for a given sampling frequency. For example, | 2 m | 10 - sample; 60 - sample, ave, min, max | means that for the sensor mounted at 2 m above ground, point samples are archived every 10 minutes, whereas samples, averages over the whole sampling period, minimum and maximum values over the sampling period are archived every 60 minutes. (*) Only on 653 at 10m. (**) Only on 652. (***) Only on 653.

3.2 The Hydrometric Station 650

At the Hydrometric Station 650 seven parameters are measured. In Table 3.2 the parameter, sensor type, sensor height above terrain and specifications are seen with the aggregation method.

parameter	sensor	range	sensitivity	accuracy
Air temperature	Campbell 107-L	-35 - 50 °C	0.1 °C	± 0.4 °C
		+2 m	30 - sample, ave, min, max	
Water level 1	Vegawell 52	0 -600 mH2O	0.01 mH2O	± 0.1 %
		Approx. -3 m	10 – sample	
Water level 2	Vegawell 52	0 - 600 mH2O	0.01 mH2O	± 0.1 %
		Approx. -3 m	10 – sample	
Water level 3	Van Essen Inst. Diver D1801	0 - 10 mH2O	0.002 mH2O	0.005 mH2O
		Approx. -3 m	60 – sample	
Water temperature 1	Van Essen Inst. Diver D1801	-20 - 80 °C	0.01 °C	± 0.1 °C
		Approx. -3 m	60 – sample	
Water level 4	Van Essen Inst. Diver D1801	0 - 10 mH2O	0.002 mH2O	0.005 mH2O
		Approx. -3 m	60 – sample	
Water temperature 2	Van Essen Inst. Diver D1801	-20 - 80 °C	0.01 °C	± 0.1 °C
		Approx. -3 m	60 – sample	

Table 3.2: Parameters measured at hydrometric station 650. For each parameter, the parts of the table underlain in blue give the sampling scheme currently in use. For several sensor types, more than one sensor is mounted at different heights, which are given in the first column, whereas the second column gives the sampling type for a given sampling frequency. For example, | 2 m | 10 - sample; 60 - sample, ave, min, max | means that for the sensor mounted at 2 m above ground, point samples are archived every 10 minutes, whereas samples, averages over the whole sampling period, minimum and maximum values over the sampling period are archived every 60 minutes.

3.3 The Diver Stations, 651, 651_2, 658, 654, 655, 656

At the diver stations four parameters are measured. In **Error! Reference source not found.** p arameter, senor type, sensor height above terrain, sensor specifications and aggregations method for H3, H4 and H5 can be seen.

parameter	sensor	range	sensitivity	accuracy
Air temperature	Van Essen Inst. Diver D1800	-20 - 80 °C	0.01 °C	± 0.1 °C
		0 m	15 - sample	
Air pressure	Van Essen Inst. Diver D1800	0 – 1.5 mH2O	0.05 mH2O	0.005 mH2O
		0 m	15 – sample	
Water level 1	Van Essen Inst. Diver D1801	0 - 10 mH2O	0.002 mH2O	0.005 mH2O
		Approx. -3 m	15 – sample	
Water temperature 1	Van Essen Inst. Diver D1801	-20 - 80 °C	0.01 °C	± 0.1 °C
		Approx. -3 m	15 – sample	
Water level 2	Van Essen Inst. Diver D1801	0 - 10 mH2O	0.002 mH2O	0.005 mH2O
		Approx. -3 m	15 – sample	
Water temperature 2	Van Essen Inst. Diver D1801	-20 - 80 °C	0.01 °C	± 0.1 °C
		Approx. -3 m	15 – sample	

Table 3.3: Parameters measured at the diver stations. For each parameter, the parts of the table underlain in blue give the sampling scheme currently in use. For several sensor types, more than one sensor is mounted at different heights, which are given in the first column, whereas the second column gives the sampling type for a given sampling frequency. For example, | 2 m | 10 - sample; 60 - sample, ave, min, max | means that for the sensor mounted at 2 m above ground, point samples are archived every 10 minutes, whereas samples, averages over the whole sampling period, minimum and maximum values over the sampling period are archived every 60 minutes.

4 Procedures

4.1 Climate and Hydrometric Station maintenance

Once per year, the climate station is visited by Asiaq personnel to perform maintenance and reference testing. This includes a check of the installation's hardware and a change of sensors where necessary. Sensors are replaced in regular intervals by freshly calibrated ones (1-2 years for temperature and humidity sensors, 2-4 years for radiation sensors; wind sensors have their ball bearings replaced every 2-4 years and the acoustic snow depth sensor has its membrane changed every 1-2 years). Malfunctioning sensors are replaced as soon as possible.

Reference tests are conducted with calibrated sensors upon arrival at the station and at the end of the visit, after sensors have been replaced. Table 4: Conducted reference tests and allowable deviations between installed and reference sensors. shows the reference tests conducted and the respective permitted tolerances for the tests.

The sensor measuring UV-B radiation is always left in place, but a calibrated reference sensor is installed and collects data during each station visit. The measurements collected by the fixed sensor are then corrected with the help of the temporary / calibrated sensor.

sensor	tolerance
air temperature	± 0.5 K
relative humidity	± 3 %
wind speed	± 1 m s^{-1}
wind direction	± 10˚
atmospheric pressure	± 0.5 hPa
shortwave radiation	± 15 W m^{-2}
snow depth	± 1 cm

Table 4: Conducted reference tests and allowable deviations between installed and reference sensors.

Field reports, detailed log sheets and photos are filled out and collected during each visit, including the serial numbers of installed sensors.

4.2 Diver Station maintenance

The river diver stations are visited at least twice per year by Asiaq personnel to switch between the summer and winter diver set up; once in the spring as soon as the locations are ice and snow free, and once in the autumn before the winter freeze up. Divers located in lakes are exchanged annually, usually in the autumn. During these visits, the water level is measured using survey grade levelling equipment and the fixed reference points at each station.

During these, or additional visits, discharge is measured at the cross sections shown in section 2 of this manual. The method of measuring discharge is chosen based on the flow conditions; for low discharge with laminar flow either OTT MF pro – Water Flow Meter or C2/C31 propeller type current meter are used, for turbulent flow and high water depths Sommer TQ Tracer system for salt or fluorescence are used. Previously a Doppler current profiler of the model Ott Q-liner has also been used for high water levels at station 650.

4.3 Data quality control

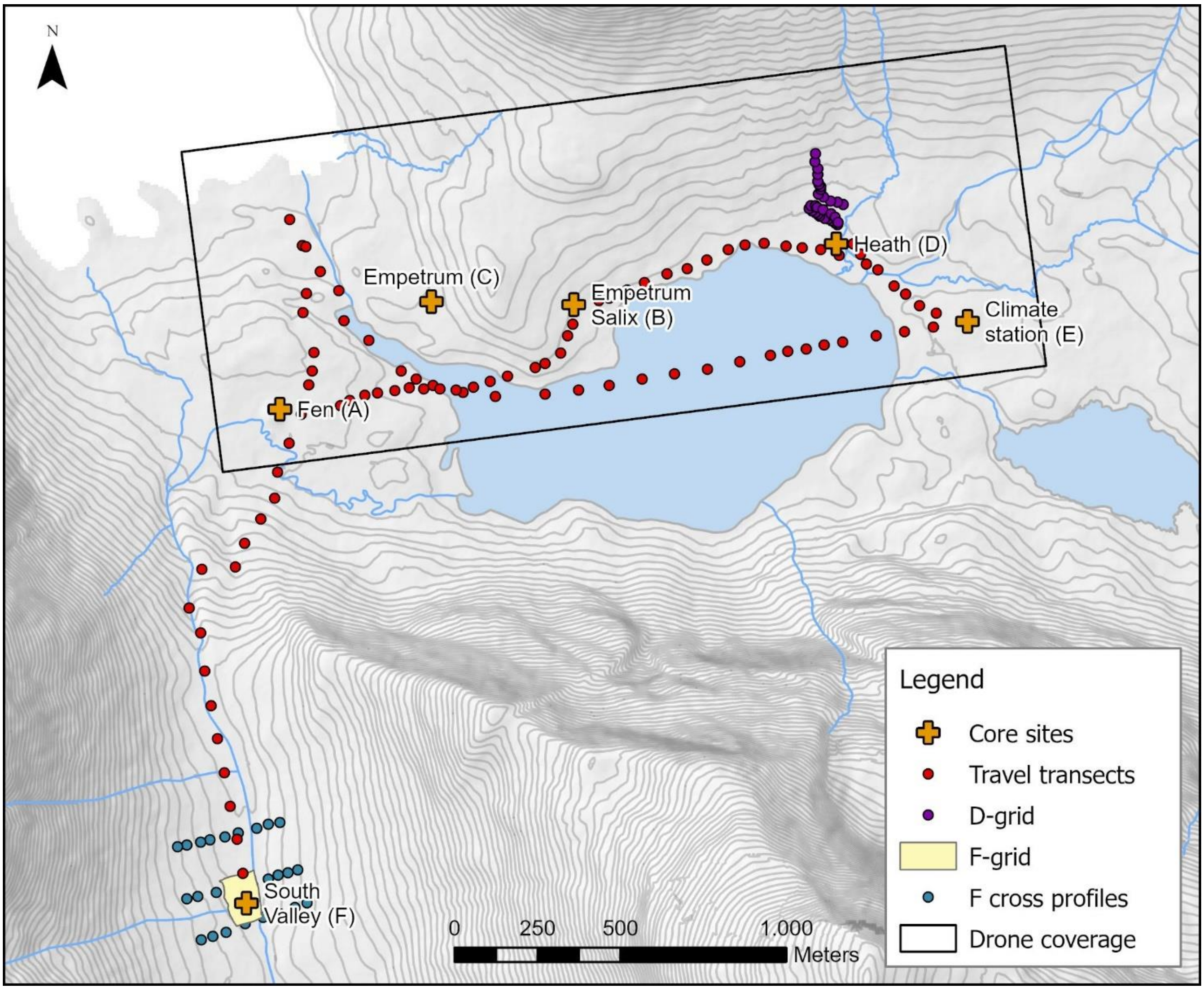
Quality control of the archived data is performed annually. Every timeseries is manually checked for unlikely values on the basis of expert knowledge. The double sensor setup is used for comparison to detect outlying values. The same parameter measured at different heights on the climate mast (as with air temperature, relative humidity and wind speed) is also used for comparisons.

4.3.1 Precipitation

The precipitation is measured at the climate stations with the accumulating Ott Pluvio^2 rain gauge. In order to minimize evaporation and prevent freezing during the winter, a mixture of antifreeze and oil (3 l / 0.5 l, respectively) is added to the gauge after emptying it during a station visit. The sensitive pressure cell of the gauge registers some noise, whose sources are still under investigation. Wind, which is usually strong during rain or snow events, presumably leads to vibrations which may be reinforced / more easily transmitted in the presence of ice and snow in and around the gauge.
The data is therefore transformed into hourly rainfall increments by first applying the “neutral aggregating filter” (NAF) by Pan et al. (2016; Smith et al., 2019) and then differencing the accumulated timeseries.
No attempt is made to correct for wind-induced undercatch; however, it should be noted that we found that the amount of solid precipitation (snow) caught by the gauge typically exceeds water equivalent calculations based on other sources (e.g. snow depth sensor).

5 Annual snow survey

A snow survey is performed each year in spring to characterize the winter snow pack. The survey consists of snow depth and spatial distribution using GNSS, drone, snow probing and snow density measurements, see Figure 5.1. The survey is carried out in collaboration with GeoBasis Nuuk and started in 2009.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Empetrum (C)
Empetrum
Salix (B)
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Travel transects
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F-grid
F cross profiles
Drone coverage

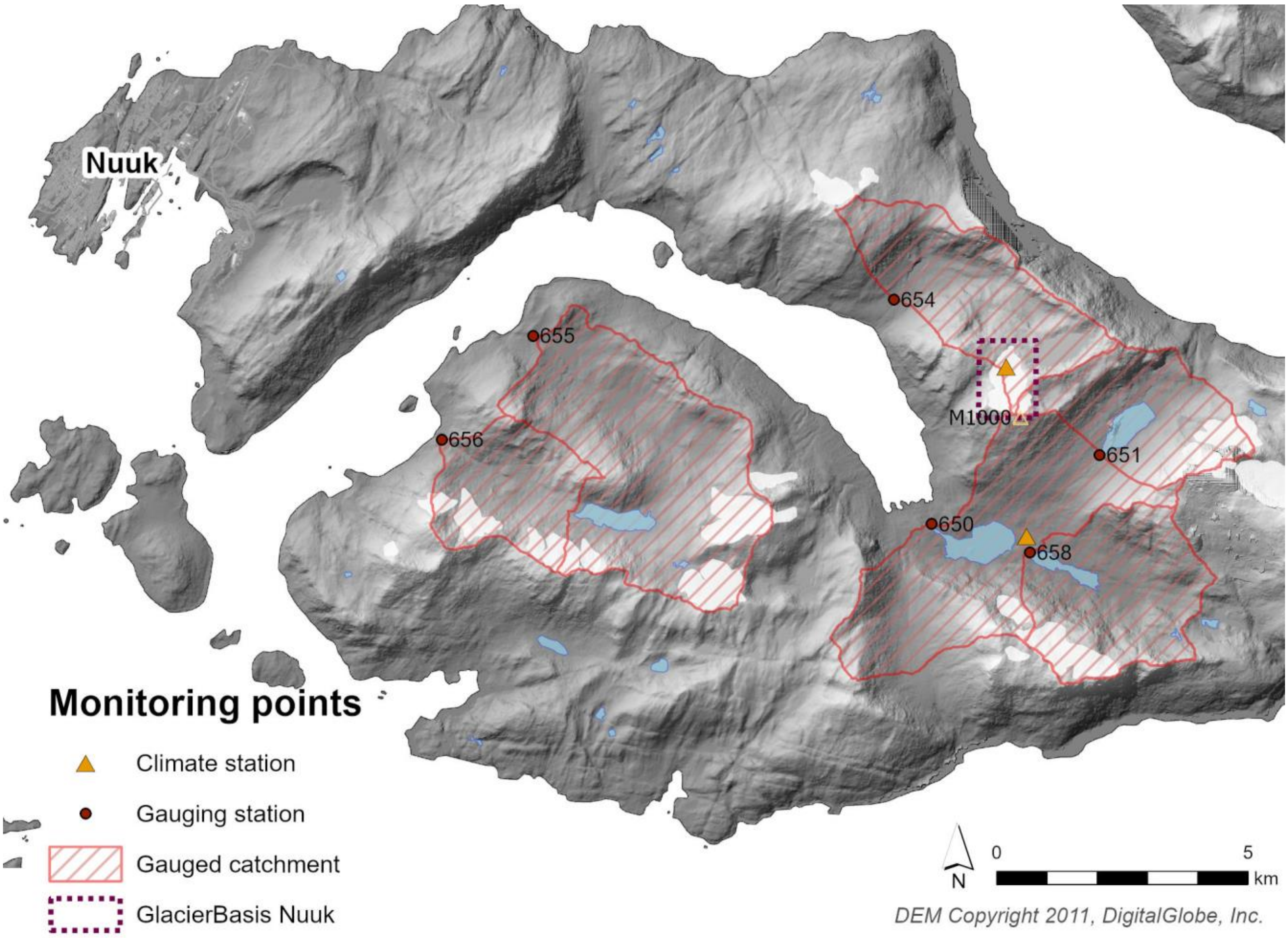

Figure 5.1 Map showing the snow survey area and typical measurements made

5.1 Snow depth

Snow depth has been measured both with manual probing and using RTK GNSS along predetermined transects, see Figure 5.1. If drone based mapping is not possible, due to weather or other issues, these measurements provide the spatial distribution of snow depth.

5.2 Drone-based snow volume mapping

A drone survey has been carried out since 2018. The survey covers about 2.5 km^2 and includes all other measurement locations. The South Valley was included for the first time in 2025. An ebee X fixed wing drone is currently used for the survey. Photogrammetry is used to construct a digital terrain model (DTM) of the area. This is then differenced with a DTM constructed under snow-free conditions to give snow depth. Figure 5.1 shows the extent of the surveyed area. Ground control points are measured in with RTK GNSS with respect to a fixed point.

5.3 Snow pits

Snow pits are dug at six locations covering a variety of ground and vegetation types, aspects and elevations. Each of the ClimateBasis and GeoBasis stations with SR50 snow depth sensors are included as a snow pit site.

In a snow pit, the shadowed side of the pit is characterized in several ways. First, a stratigraphy is constructed by identifying layers of homogeneous snow/ice properties (hardness and grain size/type). Then, the density and temperature of the snowpack is measured in increments of 10 cm; the density is measured with a standard rip cutter.