Guidelines and Sampling Procedures for the Geographical Monitoring Program

GeoBasis Disko

Part of Greenland Ecosystem Monitoring (GEM)

Version - 2025

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This edition of the GeoBasis Manual

Please note that GeoBasis procedures are subject to ongoing changes and improvements and therefore, the manual is per definition always preliminary.

If you have questions or comments about this edition, please contact:

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Acknowledgement

Part of the GeoBasis Disko monitoring is based on the DiskoBasis-program (2013-2016). GeoBasis Disko has a close collaboration with Arctic Station and appreciate very much the help and support from the staff at Arctic Station. This version of the GeoBasis Disko Manual uses guidelines and experiences given by scientific consultants, field-staff, lab-staff, technicians and managers who have been involved in the GeoBasis monitoring in Zackenberg, Nuuk, and Disko throughout the last 25 years.

Thomas Friborg and Charlotte Sigsgaard

Front cover illustration:

Preparing to deploy sensors in the river Kuussuaq (Røde Elv) in June 2024. Photo Charlotte Sigsgaard

GeoBasis monitoring program

1 Introduction

1.1 GeoBasis Disko program

The GeoBasis Disko monitoring program started in 2017 as a part of the cross disciplinary Greenland Environmental Monitoring (GEM) program. GeoBasis Disko is an integrated part of the GeoBasis program, following the same standards as in Nuuk and Zackenberg and largely focusing on the same parameters and methodologies. GeoBasis Disko is funded by Danish Ministry of Energy, Utilities and Climate.

A close collaboration and synergy with Arctic Station and the permanent staff enable data collection and measurements to run also during winter. The location on the south coast of Disko Island (Western Greenland) represents an environment on the boundary between the Low Arctic and High Arctic with an annual mean air temperature just below 0°C and discontinuous permafrost.

The primary objective of GeoBasis Disko is to establish baseline knowledge on the dynamics of fundamental abiotic terrestrial parameters within the environment/ecosystem around Arctic Station. This is done through a long-term collection of data that includes the following sub-topics:

- **Snow properties**; including spatial and temporal variation in snow cover, depth and density.
- **Soil properties**; spatially distributed monitoring of key soil parameters such as temperature, moisture, and concentration of nutrient ions.
- **Meteorology**; monitoring of essential meteorological variables across various surface types and elevations.
- **Gas Fluxes**; plot and landscape scale flux monitoring of CO2, H2O and energy in wet and dry ecosystems.
- **Hydrology**; monitoring of seasonal variation in river water discharge, chemistry and suspended sediment.
- **Geomorphology**; monitoring of shorelines, delta progression/retreats.

GeoBasis focuses on selected abiotic parameters to describe the state of Arctic terrestrial environments and their potential feedback effects in a changing climate. As such, inter-annual variation and long-term trends are of paramount importance.

1.2 GeoBasis Disko data

Data from the GeoBasis monitoring program is freely available for research and education through the GEM database **http:/g-e-m.dk**. When downloading data, you will receive metadata about the data set and Terms of Use.

You can find selected data and significant findings from each field season in GEM Annual Report Cards published by Aarhus University, DCE –Danish Centre for Environment. And you can see updates on activities on social media: @GEM_Arctic and @ArcticStationUC, @NuukNERO, @ZERO74N.

1.3 GeoBasis Disko Study site

The activities of the GeoBasis program on Disko are concentrated around the Arctic Station in Qeqertarsuaq, West Greenland (69°15’N, 53°31’W). M.P. Porsild built Arctic Station in 1906. The site was selected due to the high plant diversity on the border of Arctic and Subarctic plant zones. The Polar night lasts from 29 November to 11 January and the Polar day lasts from 20 May to 22 July.

The island of Disko is about 8600 km^2 and located on the central west coast of Greenland. The island consists of Tertiary lavas, and the landscape is a typical arctic plateau basalt landscape with cirque carved lava plateaus and U-shape valleys and fjords. The highest land surfaces in the southwestern part near the Arctic station are about 800 m above mean sea level (amsl). The present glaciation level in the southwestern part of Disko Island is between 600 and 800 m amsl. The maximum glaciation during the Weichsel period occurred in its final phase, about 10,000 years ago. After that, the area has iso-statically raised at a rate over the eustatic sea level rise, which leads to a relative sea level fall. The highest and thus oldest sea level indicators are at about 100-110 m amsl near the Arctic Station.

The Lyngmarksfjeld and Skarvefjeld are two plateaus of Tertiary basalts to respectively the northwest and northeast of the Arctic Station (Figure 1). These plateaus are interrupted by a large U-shape glacial valley, Blæsedalen, which has a North-South orientation. The valley has been glaciated, and a large moraine (Pjeturssons moraine) is cutting off the valley at about a kilometer north of the present shoreline. The glacier was probably lying in the South, and a meltwater plain was formed north of this moraine.

Figure 1. Topographic map of the area around Qeqertarsuaq. The river Røde Elv is running in the valley between the mountains Lyngmarksfjeldet and Skarvefjeldet.

The slopes of the valley are relatively steep and characterized by many basalt blocks on the upper slopes and solifluction lobes on the lower slopes. The valley floor is at about 60 m amsl on the meltwater plain in the north and decreases towards 4 m amsl in the south. The river Kuussuaq (Røde Elv) is running through the valley. Røde Elv runs from north to south as a braided river through the melt water plain of Blæsedalen and cuts through the western part of the Pjeturssons moraine ridge where it narrows to a single channel in the basalt outcrops before it runs into the sea.

The shores near the Arctic Station consist of an alternation of hard-rock headlands and sedimentary stretches. Most of the sediments in the sedimentary stretches are delivered by (relatively small) rivers. The erosion of the hard-rock cliffs in the adjacent sections will only marginally contribute to the sediment budget. This means that most of the sediments near the Arctic station come from the Røde Elv. These sediments create a very small delta at the shore and a shallow low-tide terrace at the river mouth. This low-tide terrace is further reworked during high-tide and storm events by waves and currents. Wave processes align the adjacent shores, and a barrier was formed between the headland of Qeqertarsuaq and the delta of Røde Elv. This barrier encloses a lagoon. The shoreline is probably in a transgressive stage at present.

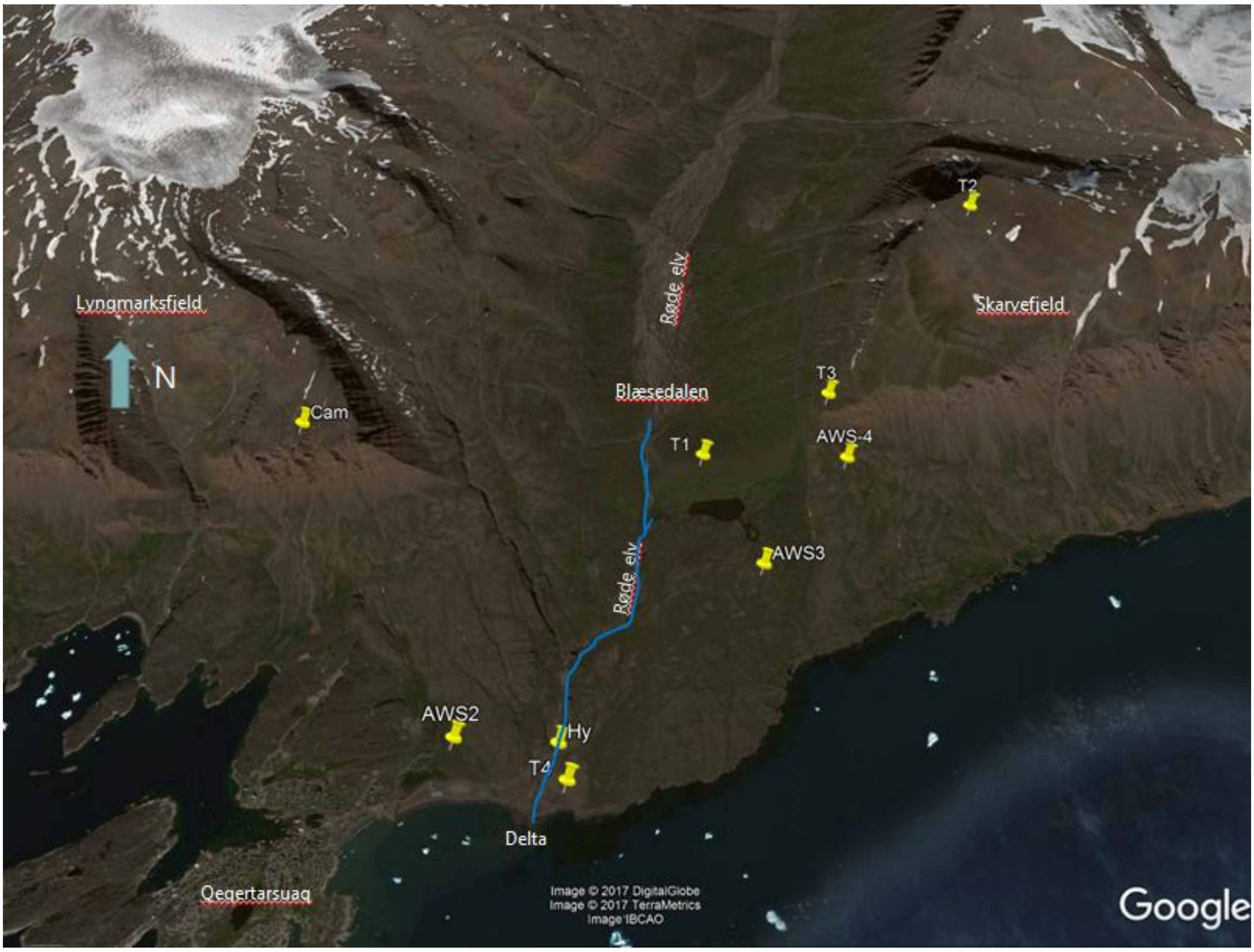
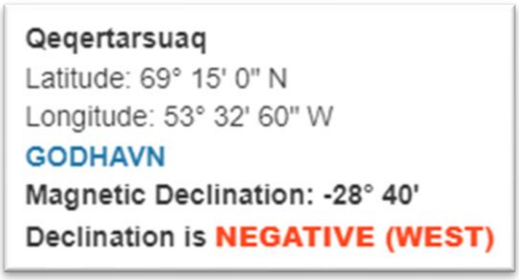


Figure 1.1 Location of main sites for GeoBasis. Arctic Station is located near Automatic weather station AWS2 in Østerlien. T1-T4 refers to temperature masts. Hy is the site for hydrological monitoring. The background satellite image is copied from Google Earth and shows the very southern part of Disko Island West Greenland.

Magnetic declination



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Magnetic declination is calculated using the World Magnetic Model WMM2020.

1.4 GeoBasis Staff and Scientific consultants

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2 Automatic Weather Stations

2.1 Introduction

Monitoring of essential meteorological variables across various surface types and elevations are part of GeoBasis. Meteorological parameters have been recorded since 1991 where an automatic weather station was established next to the scientific leader's house. Data from this station (called **AWS1)** is now made available in the GEM database. Data collection from AWS1 ends in the summer of 2018 when the station was removed. In August 2012, a new automatic weather station (**AWS2**) was installed in Østerlien just east of Arctic Station. More weather stations were included over the years; **AWS3** in 2013, **T1, T2, T3, and T4** in 2014, and **AWS4** in 2015 (Figure 2.1). Together these stations represent an altitudinal gradient from sea level to 830 m asl. All stations measure air temperature but apart from that, the stations are not equally equipped. AWS2 measures most parameters whereas T1-T4 records air- and ground-surface temperature only.

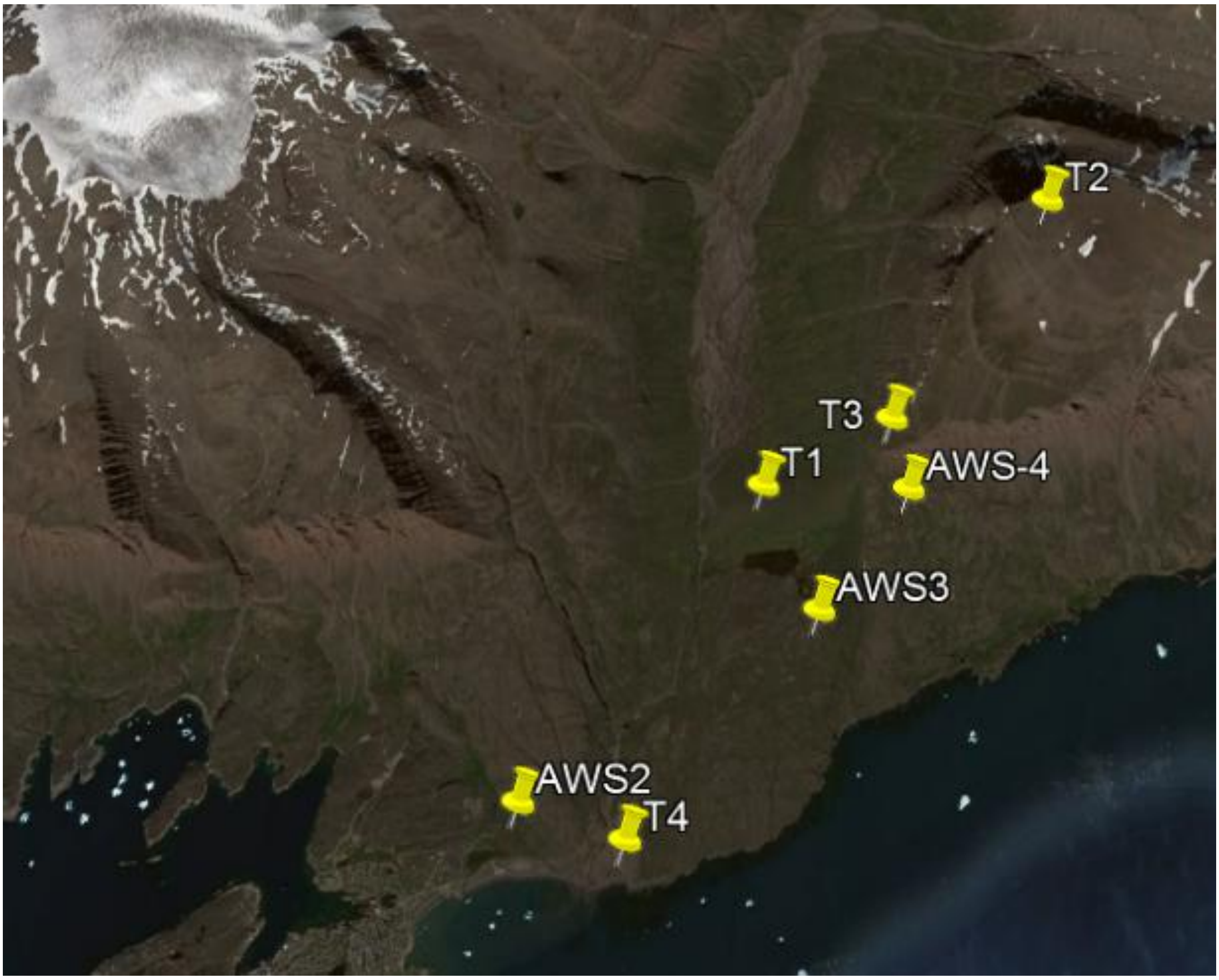


Figure 2.1. GeoBasis automatic weather stations in the landscape around Arctic Station. The stations cover an altitudinal gradient from sea level (T4) to 830 m asl (T2).

The mean annual air temperature from 1992 to 2023 was -2.7 °C (Figure 2.2). Annual means have increased, especially in the 1990´s primarily due to increasing winter temperatures. Mean monthly air temperatures vary a lot during winter and less during summer. In general, February and March are the coldest months and July the warmest month. The maximum air temperature registered was 21.9 °C and the lowest temperature was 32.9°C (recorded at AWS1 from 1991-2018).

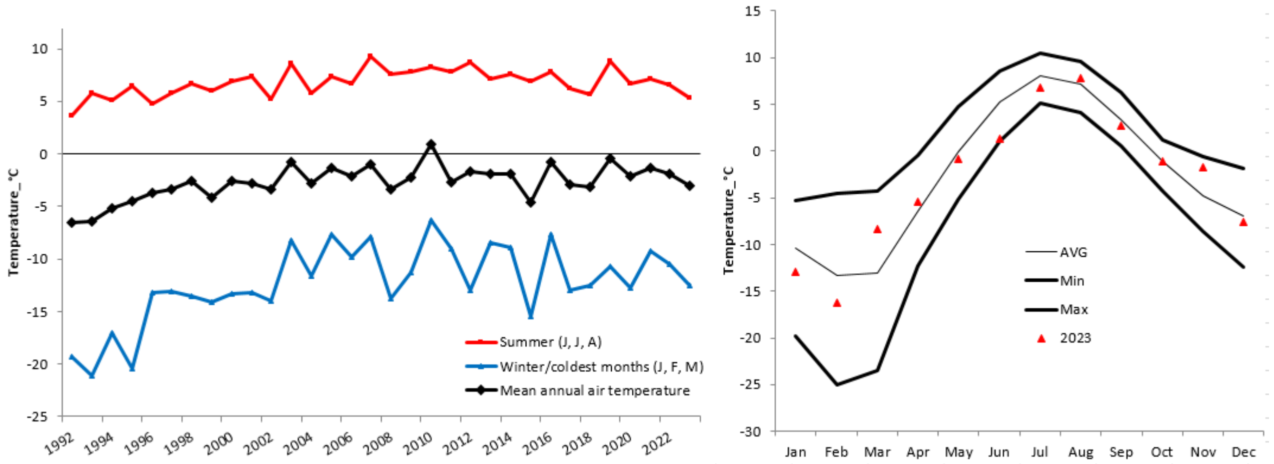


Figure 2.2 Annual mean air temperatures at Arctic Station from 1992 to 2023 (left) and mean monthly air temperatures (min, max, and average) for the period 1992-2022 and for 2023 (right)

Where to find data in the GEM Database

In the GEM database all GeoBasis Disko data are in Greenlandic Standard Time (UTC-3)

Programme/Programme group/Group-element

GeoBasis Disko / Meteorology / AWS2-Meteorology

GeoBasis Disko / Meteorology / AWS3-Meteorology

GeoBasis Disko / Meteorology / AWS4-Meteorology

GeoBasis Disko / Meteorology / T1-Temperature_125m

GeoBasis Disko / Meteorology / T2-Temperature_830m

GeoBasis Disko / Meteorology / T3-Temperature_400m

GeoBasis Disko / Meteorology / T4-Temperature_1m

GeoBasis Disko / Snow / AWS2-SnowAirTemperature

GeoBasis Disko / Snow / AWS2-SnowDepth

GeoBasis Disko / Soil / AWS2-GroundSurfaceTemperature

GeoBasis Disko / Soil / AWS2-GroundTemperatureProfile1

GeoBasis Disko / Soil / AWS2-GroundTemperatureProfile2

GeoBasis Disko / Soil / AWS2-SoilHeatFlux

GeoBasis Disko / Soil / AWS2-SoilMoisture

GeoBasis Disko / Soil / AWS2-SoilTemperature

GeoBasis Disko / Soil / AWS3-SoilMoisture

GeoBasis Disko / Soil / AWS3-SoilTemperature

GeoBasis Disko / Soil / AWS4-SoilMoisture

GeoBasis Disko / Soil / AWS4-SoilTemperature

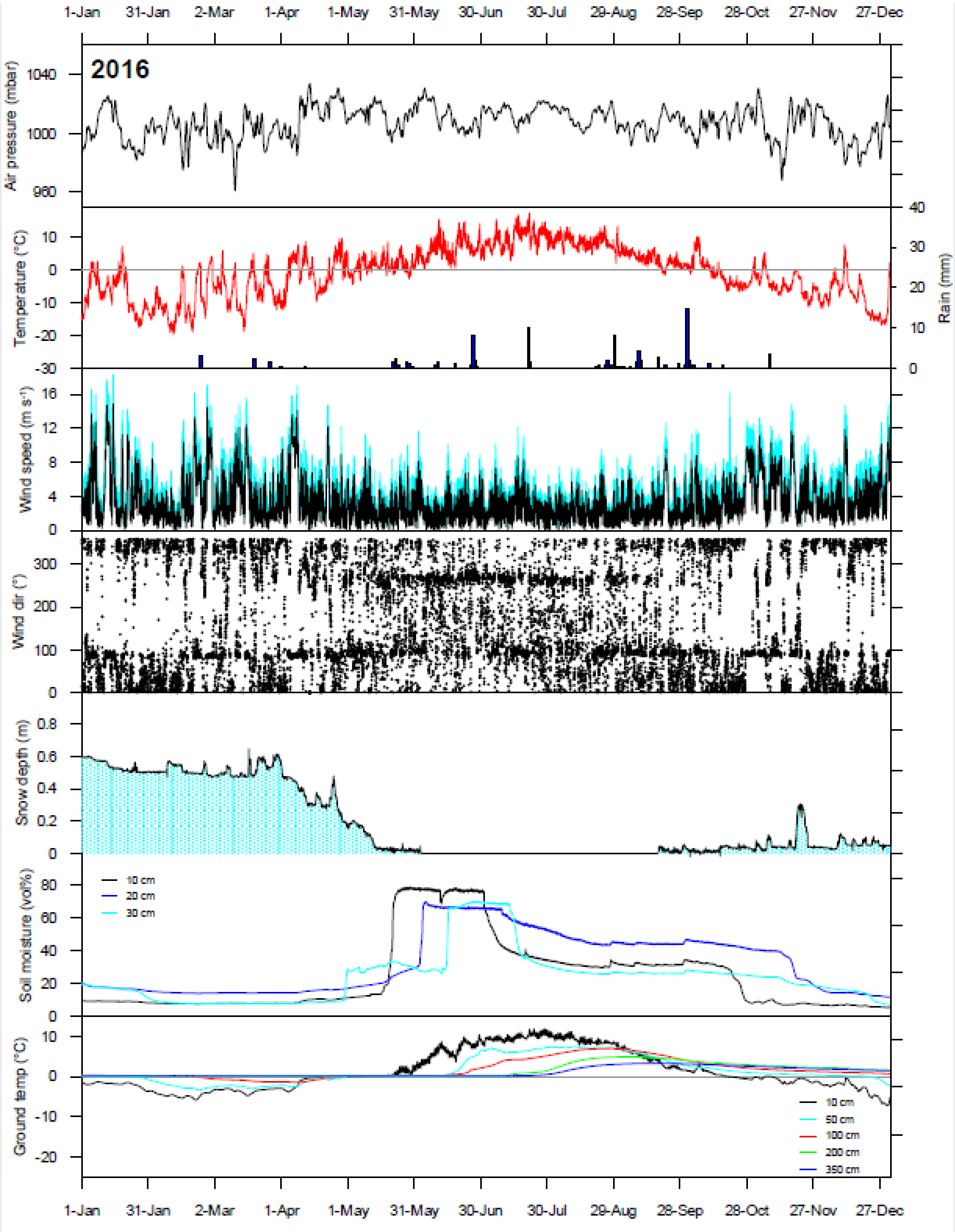


Figure 2.3. Temporal variations of selected parameters from the automatic weather station (AWS2) in Østerlien in 2016 (data logged every 30 min). Air Pressure, air temperature, precipitation (rain measured at AWS1), wind speed (mean and max), wind direction, snow depth, soil moisture and ground temperatures from 10, 50, 100, 200 and 350 cm.

2.2 Automatic Weather Station AWS2- Østerlien

The station in Østerlien consists of two masts; AWS2 where common meteorological and energy balance parameters are measured, and EC1 where micrometeorological/gas flux parameters are measured by use of eddy covariance technique (Figure 2.4). Finally, there is a separate metal pole where soil temperatures and air/snow temperatures are measured. For a list of instrumentation, see **Appendix 1**.

AWS2 Østerlien

AWS2 is located 100 m west of Arctic Station in a gentle south sloping area covered by low vegetation/dwarf shrubs.
Position (decimal degrees): 69.2535°N, -53.5141°
Elevation: 25 m a.s.l. (Google Earth)
Operation: 2012-
Instrumentation of the mast: see Appendix 1
Power: cable from Arctic Station, solar panel
Datalogger: CR1000x
Time: UTC-3
Logging interval: 30 min

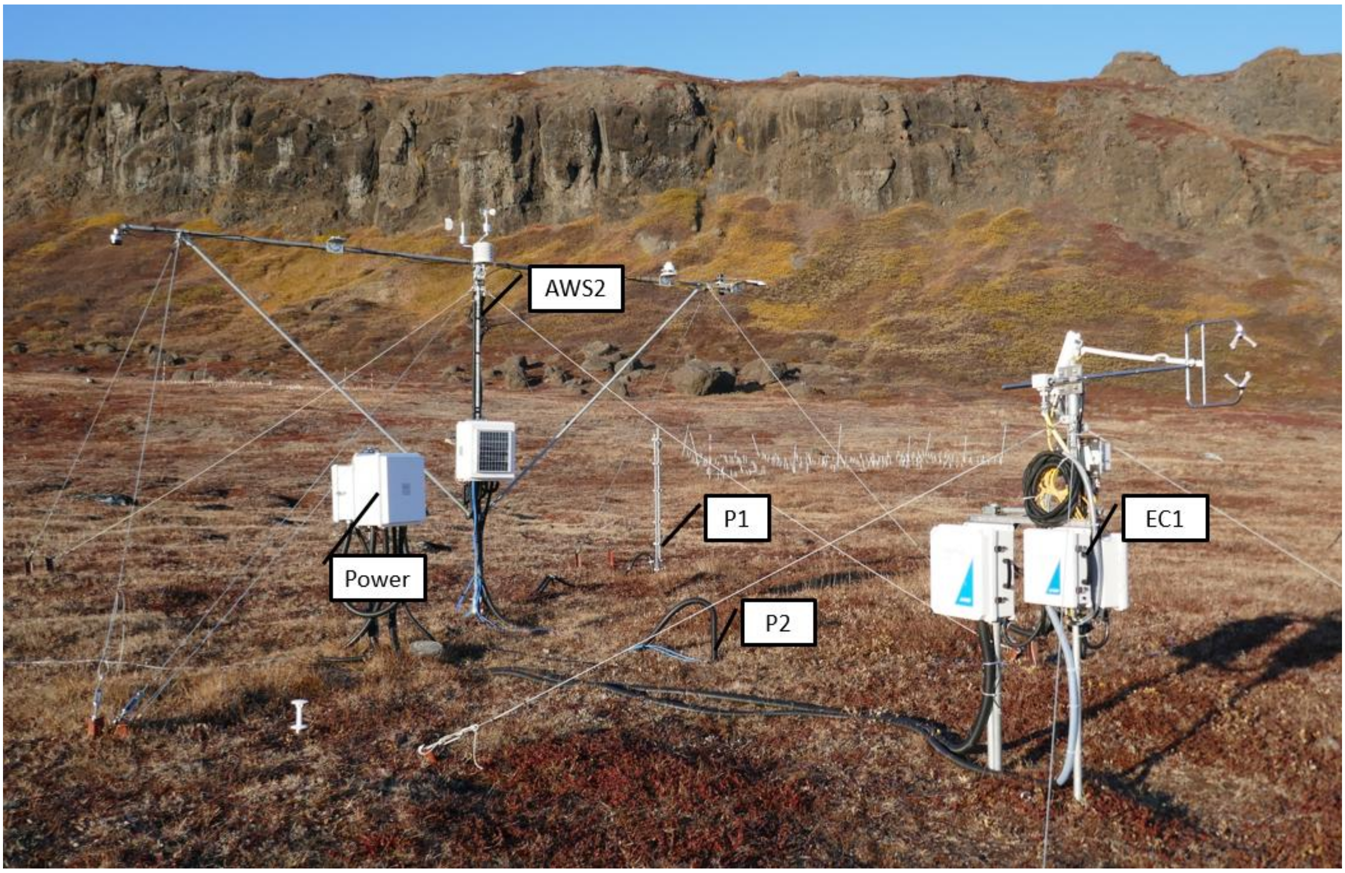


Figure 2.4 The Automatic Weather Station AWS2 and the Eddy Covariance Mast EC1. P1 and P2 are boreholes with temperature sensors down to 150 cm and 350 cm, respectively. The power box has a buried line power connection to Arctic Station.

Figure 2.5 The Automatic Weather Station AWS2 in Østerlien. 1) Snow depth (SR50 Sonic sensor), 2) PAR sensor, 3) Sonic Wind direction and Wind speed, 4) UVB sensor, 5) SKYE sensor RED/NIR. 6) Net radiometer CNR4, 7) Temperature and humidity sensor.

The meteorological mast of the weather station is 3 m high with an east west oriented crossbeam with mounted sensors (Figure 2.5). P1 and P2 are boreholes equipped with temperature sensors down to 150 cm and 350 cm, respectively (Figure 2.4). Next to P1, there are soil moisture sensors and soil heat-flux sensors in the ground. The eddy covariance mast (EC1) is equipped with a 3D sonic anemometer (Gill-HS) placed 2 m above terrain and a Licor-7200RS gas analyzer (see more about gasflux monitoring in section 3).

2.2.1 Offloading data from AWS2-Østerlien

Data from AWS2 and EC1 are stored on a computer in the garage at Arctic Station (Figure 2.6). Data is uploaded to a server at the University of Copenhagen. On the computer screen you can see live update from the Licor-7200 and check that values look reasonable –change settings and so on.

Frequency

Check at least once a week and after any work with the station that data from AWS2 and EC1 are transferred to the repository folders at IGN. This routine check is done by the datamanager.

Figure 2.6 Location of the computer in the AS Garage 1st floor. A buried cable links the computer in the garage and the weather station (AWS2) and the eddy covariance mast (EC1) in Østerlien. <u>Only GeoBasis staff have access to this computer.</u>

Procedure for offloading

Data from AWS2 and EC1 are transferred to the IGN server in Copenhagen daily.

Data from AWS2 is found here:

I:\SCIENCE-CENPERM-DATA01\AS_DATA_UPLOAD_REPOSITORY\AS_CR1000X_UPLOAD

CR1000XSeries_Biomet.dat	11-01-2023 14:42	DAT File
CR1000XSeries_Daily.dat	11-01-2023 14:41	DAT File
CR1000XSeries_DataTableInfo.dat	11-01-2023 15:04	DAT File
CR1000XSeries_MetData.dat	**CR1000MetData.dat (contains meteorological parameters)**	
CR1000XSeries_MUX2.dat	**CR1000MUX2.dat (contains all soil temperature data).**	
CR1000XSeries_shf_caldata.dat	11-01-2023 14:41	DAT File
CR1000XSeries_SoilMet2_SHFSC_30min.dat	11-01-2023 14:41	DAT File
CR1000XSeries_SoilmetICOS.dat	11-01-2023 14:42	DAT File
CR1000XSeries_SoilVue10.dat	11-01-2023 14:41	DAT File
CR1000XSeries_Status.dat	11-01-2023 15:04	DAT File

And data from EC1 are found here:
I:\SCIENCE-CENPERM-DATA01\AS_SMARTFLUX_UPLOAD

2022-04-07T033000_AIU-2008.zip	07-04-2022 09:16	Compressed (zipp...	14 KB
2022-04-07T040000_AIU-2008.ghg	07-04-2022 09:46	GHG File	2,892 KB
2022-04-07T040000_AIU-2008.zip	07-04-2022 09:46	Compressed (zipp...	14 KB
2022-04-07T043000_AIU-2008.ghg	07-04-2022 10:16	GHG File	2,928 KB
2022-04-07T043000_AIU-2008.zip	07-04-2022 10:16	Compressed (zipp...	14 KB
2022-04-07T050000_AIU-2008.ghg	07-04-2022 10:46	GHG File	2,886 KB
2022-04-07T050000_AIU-2008.zip	07-04-2022 10:46	Compressed (zipp...	14 KB
2022-04-07T053000_AIU-2008.ghg	07-04-2022 11:16	GHG File	2,879 KB
2022-04-07T053000_AIU-2008.zip	07-04-2022 11:16	Compressed (zipp...	14 KB

Quick validation and review of data from AWS2

To verify that sensors are (and have been) working satisfactorily prepare a worksheet with a copy of data

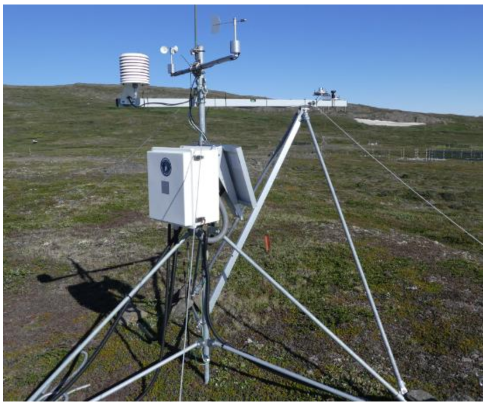
- Check that the last logged value fits with the actual year, date and time for offloading the data logger.
- Check that the time series is OK (no missing time steps). Insert a column of correct times and compare with the actual date/time column.
- Create plots of every single parameter for a quick visual inspection of the data. Verify that seasonal variations and the range of data look reasonable.
- Fill out the station log (see section 2.6)
- If anything looks suspicious or if a sensor has failures or major dropouts, please email a report to the GeoBasis data manager.

2.3 Automatic Weather Station AWS3-Blæsedalen

In July 2013, an automatic weather station (AWS3) was installed in Blæsedalen within the CENPERM experimental site. The station consists of a tripod mast (2 m) with a crossbeam. A tipping bucket sensor was installed in 2014 for liquid precipitation recordings. In 2016, a bulk precipitation collector was mounted 25 meters from the station (see section 9).

Figure 2.9 AWS3 in Blæsedalen. Looking north into Blæsedalen. The mast to the left holds the precipitation collector.

AWS3 Blæsedalen



Located in Blæsedalen in an open gently rolling area. It is a relatively dry area covered by low heath vegetation/ dwarf shrubs. Only a thin layer of soil covers the bedrock.
Position (decimal degrees): 69.26552°N, -53.46732°
Elevation: 90 m a.s.l.
Operation: 2013-
Instrumentation of the mast: see Appendix 1
Power: Solar panel and battery
Datalogger: CR1000
Time log: UTC-3
Logging interval: 30 min

Figure 2.10 AWS3 Blæsedalen. 1) Wind direction, 2) Wind speed, 3) rain, 4) PAR, 5) NDVI, 6) Air temperature and relative humidity

2.3.1 Offloading data from AWS3 Blæsedalen

Offload data from the CR1000 datalogger via direct cable connection.

Frequency

Offload data from AWS3 at least twice a year. When the field season starts in May/June and again when the field season ends in September/October.

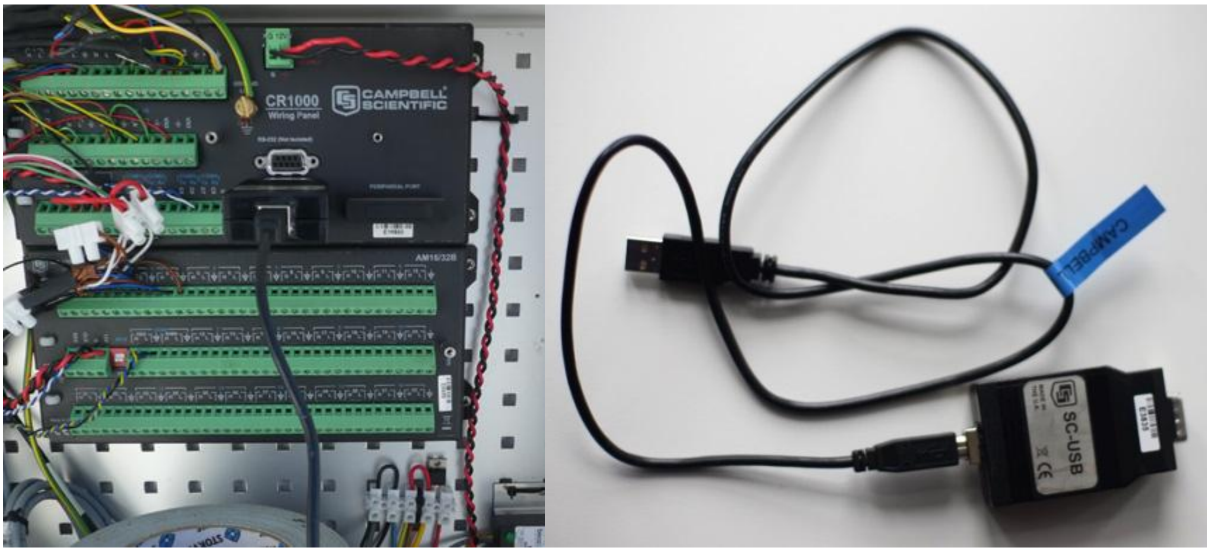
What to bring

- Laptop with the Campbell software **Loggernet** installed
- Communication cable from Campbell (USB to serial) SC –USB
- Camera
- Voltmeter
- Silica bags

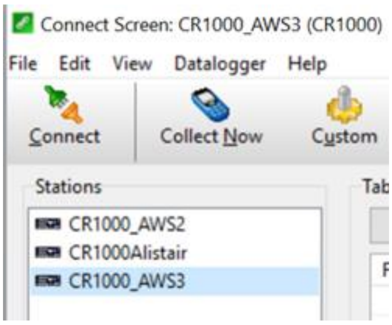
Procedure

- Enter the station via the boardwalk and open the white enclosure

- Connect the cable to the CS I/O port on the datalogger and to the USB port on the computer (see photo below)



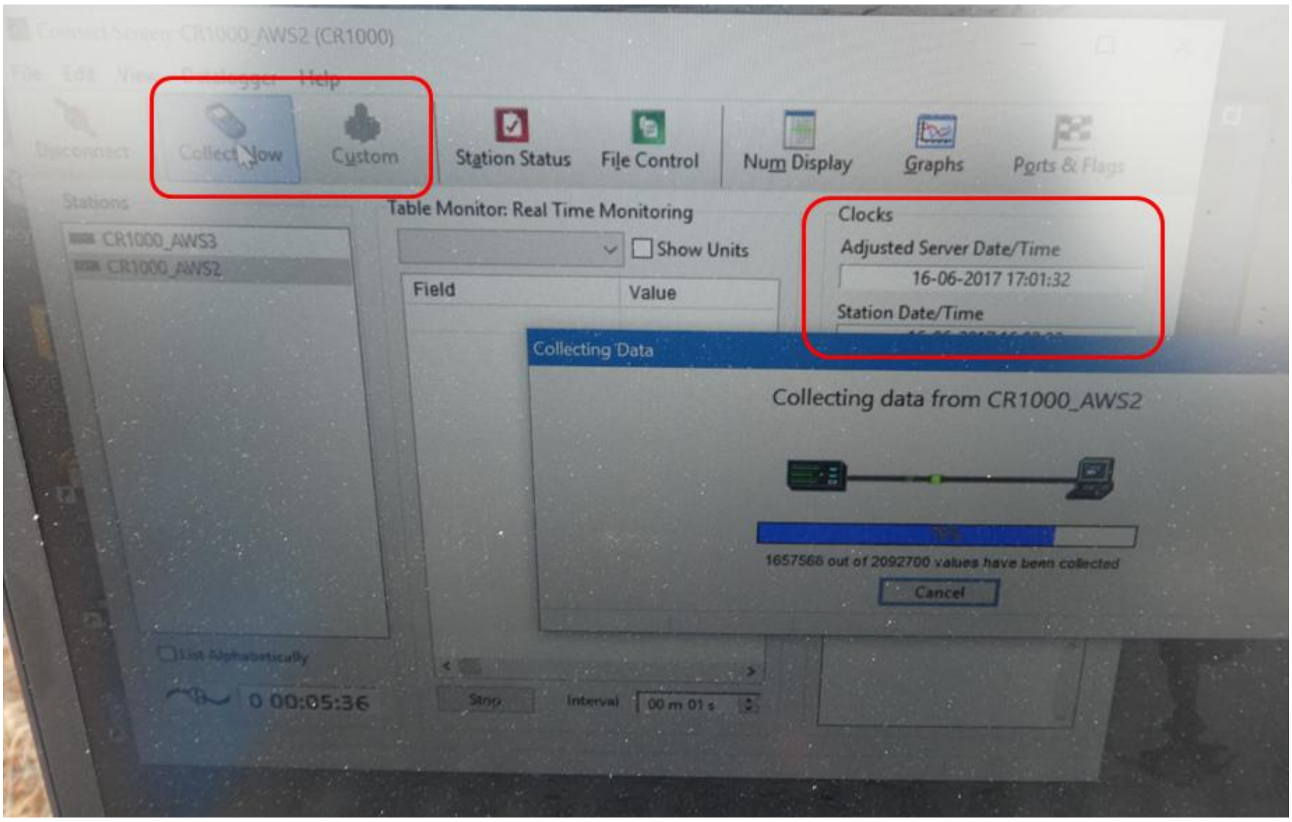
- From the main menu in Loggernet select [Connect]



- Select station CR1000_AWS3 from the station list and press [Connect] (if you receive a failure notice, please check troubleshooting 2.3.2)

- When the connection is established, the screen shows the name of the current program. If you are about to make any changes to the station always retrieve the actual program and collect data before you make any changes (see section 2.7). In the lower left corner of the screen time starts to run when connected and the **Connect** Icon switches to **Disconnect**

- Press [Collect Now] if you want to collect all data from the logger. Press [Custom] if you want to collect data from a specific period (see screen dump below).



- Data are stored in the default path (C:/Campbellsci/Loggernet/). Copy data from here to the GeoBasis folder: GeoBasis/AWS3 Blæsedalen/Original data. Remember to add the current date to the filename.

- Check and note the Adjusted server Date/Time + Station Date/Time on the screen (main menu –see above screen photo). AWS3 is running UTC-3.

- Press [Dis-connect] on the Loggernet screen and remove the cable from the datalogger.

- Take photos of the mast, sensors and surroundings for general documentation.

2.3.2 Troubleshooting

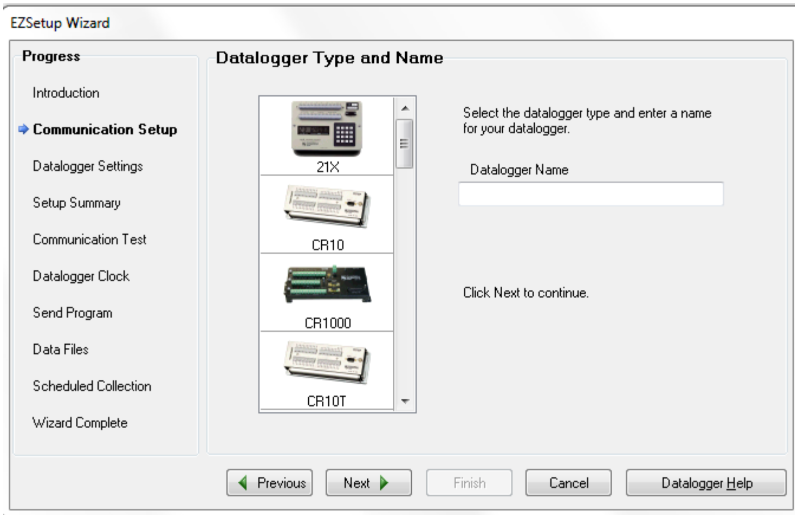
If you cannot connect with the datalogger:

Check power on the battery inside the enclosure. If the power is OK (between 12 and 14 V) then try to create a new set-up for the station.

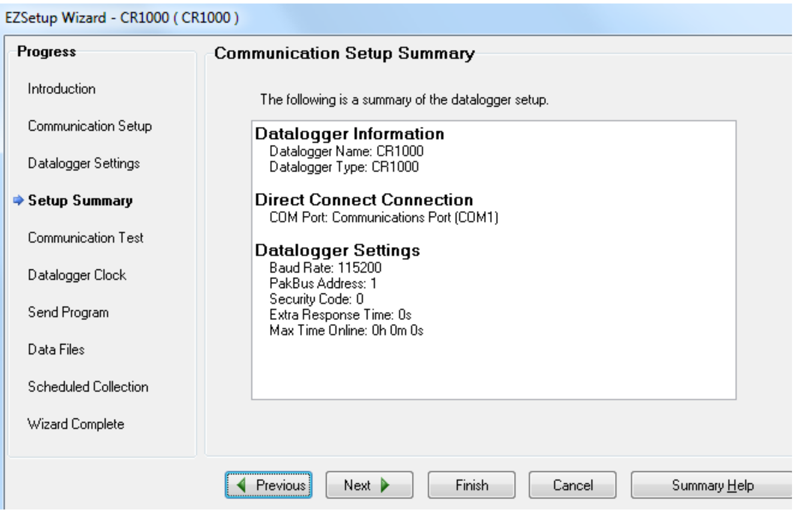
How to add a datalogger to loggernet

- In the Loggernet Main menu select **[Setup]**
- Press **[Add**] and press [**Next**]

- Under Communication Setup choose data logger type and press [**Next**]



- Choose '**Dirrect Connect**'
- Press **[YES]** to the suggested COM-ports and Pakbus addresses



- Press **[Finish]** after the Setup Summary

The added data logger is now visible when you connect to the data logger with Loggernet.

Quick validation and review of data

To verify that sensors are (and have been) working satisfactorily prepare a worksheet with a copy of data

- Check that the last logged value fits with the actual year, date and time for offloading the data logger.
- Check that the time series is OK (no missing time steps). Insert a column of correct times and compare with the actual date/time column.
- Create plots of every single parameter for a quick visual inspection of the data. Verify that seasonal variations and the range of data look reasonable.
- Fill out the station log (see section 2.6)
- If anything looks suspicious or if a sensor has failures or major dropouts, please email a report to the GeoBasis Data manager.

2.4 Automatic Weather Station AWS4- Skarvefjeld

The automatic weather station AWS4 is located 240 m asl on the southern slope of the mountain Skarvefjeld (Figure 1.1 and 2.12).

AWS-4 Skarvefjeld

Located 240 m above sea level on the southern slope of the mountain Skarvefjeld.
Position: Decimal degrees: 69.27282°N, -53.45363°
Elevation: 240 m a.s.l.
Operation: 2015-
Instrumentation of the mast: see Appendix 1
Power: Solar panel
Datalogger: HOBO U30 station from Onset
Time stamp: (UTC-2)
Time stamp in the GEM database (UTC-3)
Logging interval: 30 min

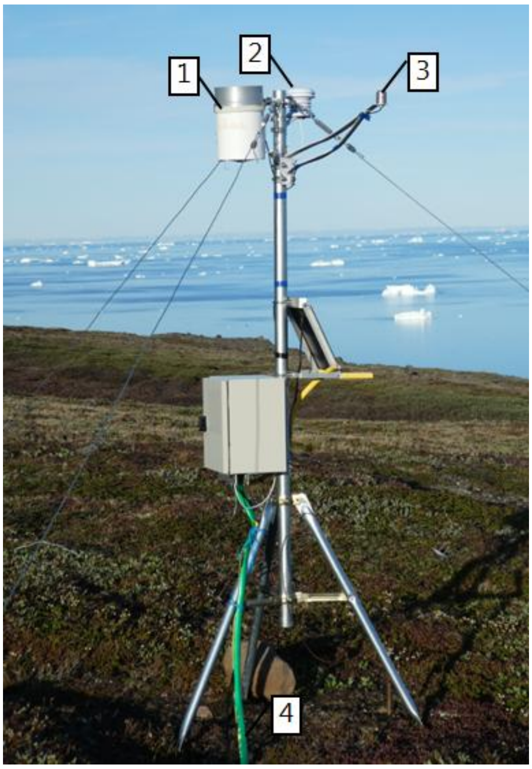


Figure 2.12. AWS4. Looking towards southeast. 1) Precipitation tipping bucket, 2) Air temperature and humidity, 3) incoming solar radiation, 4) soil temperature and soil moisture.

2.4.1 Offloading data from AWS4- Skarvefjeld

Frequency

Offload data from AWS4 at least twice a year. When the field season starts in May/June and again when the field season ends in September/October.

What to bring

- Laptop with HOBOware Pro software installed
- Camera
- Voltmeter
- Silica bags
- GeoBasis manual and HOBO U30 station User guide (GeoBasis/Manuals/HOBO U30)
- Scotch 33+ tape
- Small screwdriver or multitool

Procedure

- Inside the enclosure on the mast, there is a box with the HOBO U30 datalogger. Inside the box, you find the communication cable (Remember to leave it there). Connect the cable to the slot marked with a circle (Fig 2.13) and to the laptop. Start HOBO Pro software.

Figure 2.13 Inside the enclosure is the HOBO U30 box. The red circle marks the communication slot

Diagram

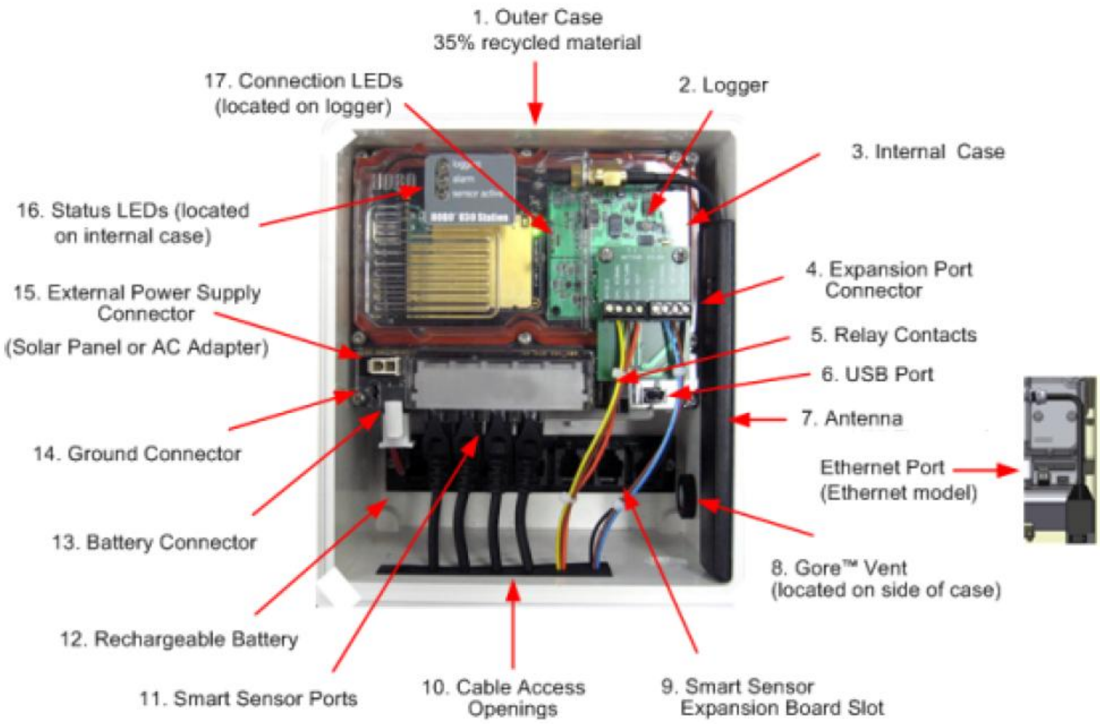
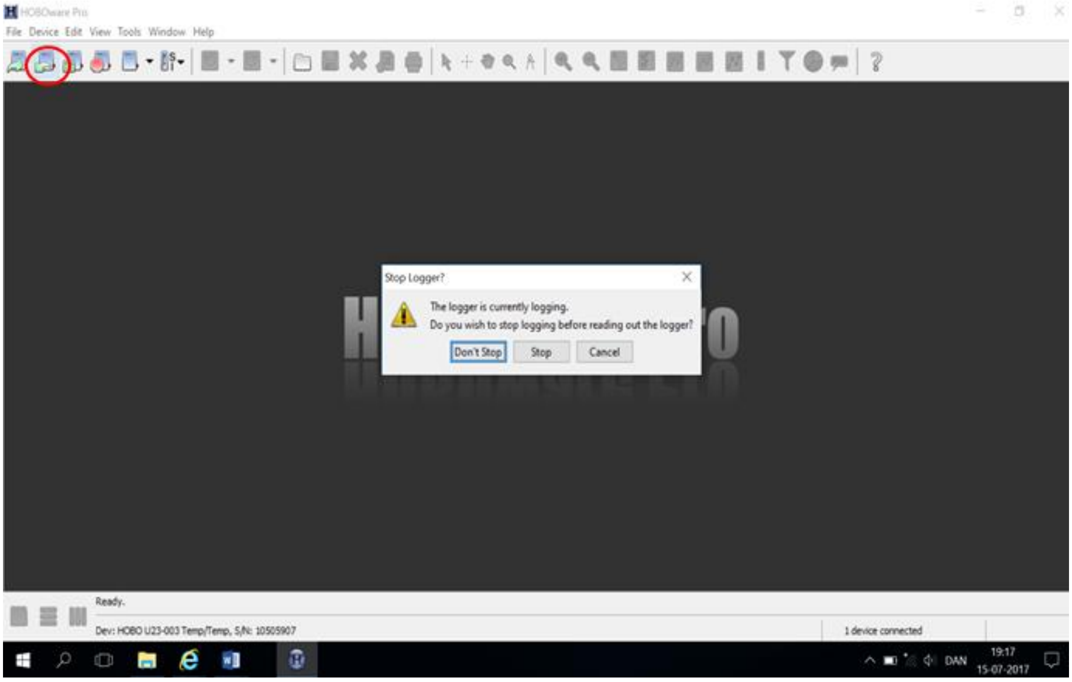


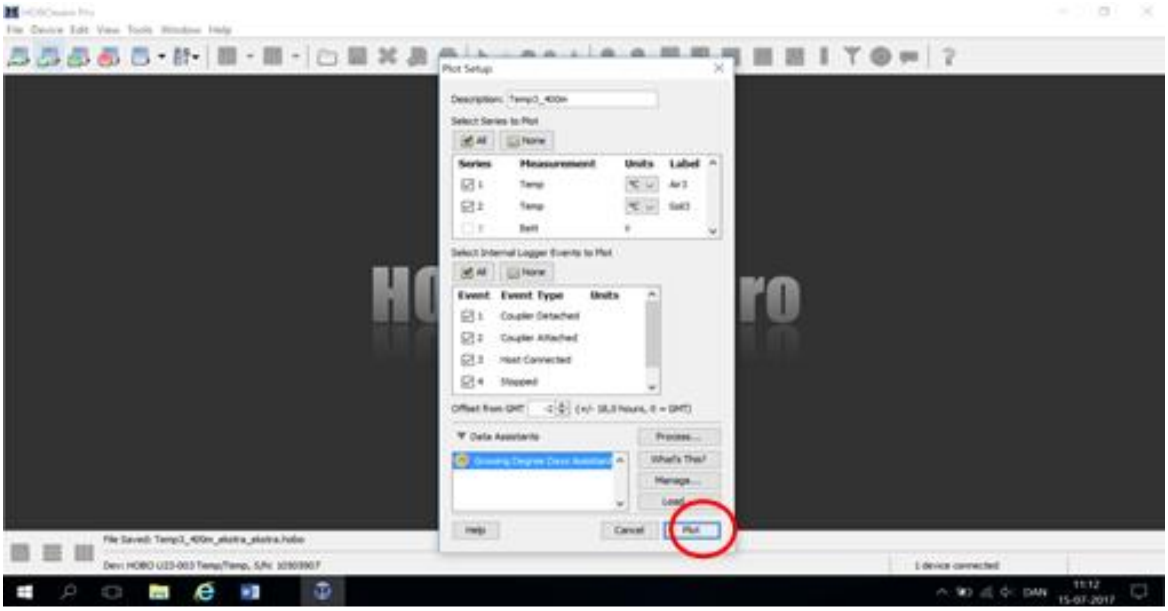
Figure 1: U30 Components

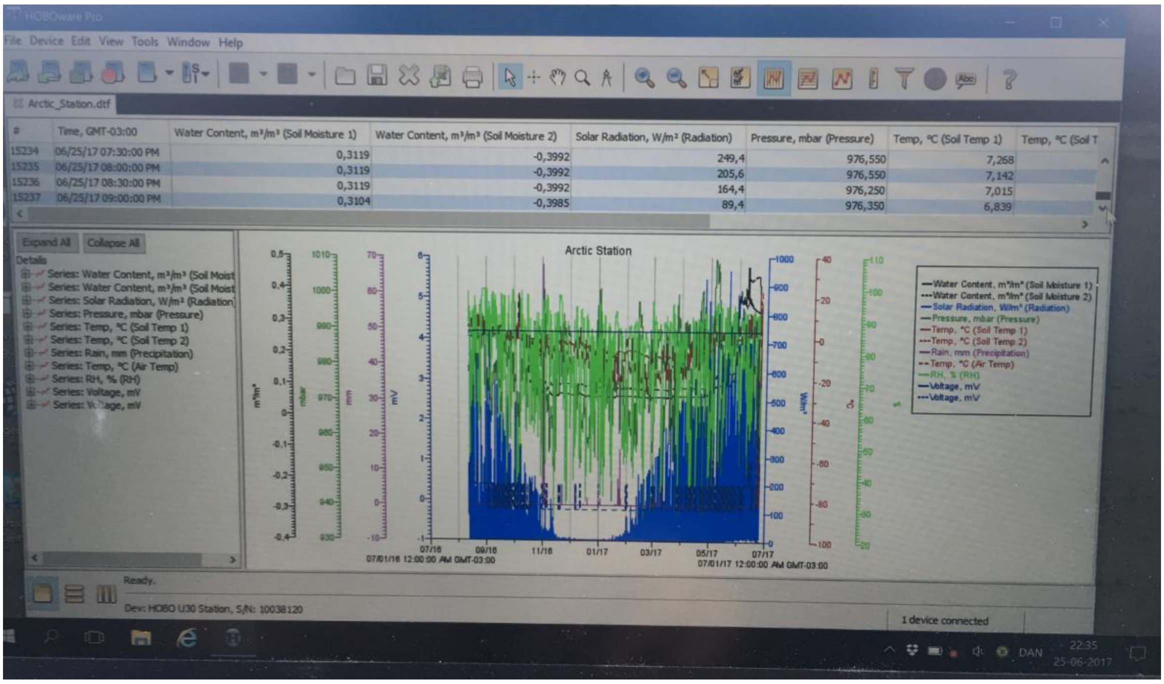
Important: Always connect or disconnect external power before the battery. Damage may occur if the battery is unplugged before the external power is disconnected.

- Press [Read out device] in the main menu (marked with a red circle). You can offload data without stopping the logger. However, at least once a year the logger must be stopped and re-launched to clear the memory and gain free space for data storage (<u>When logging every 30 min this logger holds data for 1.2 years).</u>

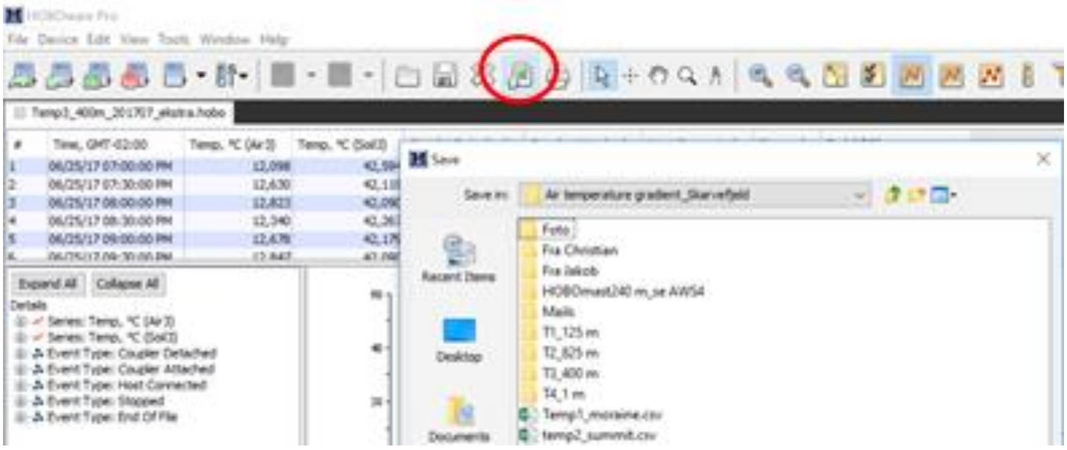


- Select where to save offloaded data and press [Save]. The offloaded data file is now saved.
- In the window **Plot Setup** press [Plot] in the lower right corner to see the data plotted

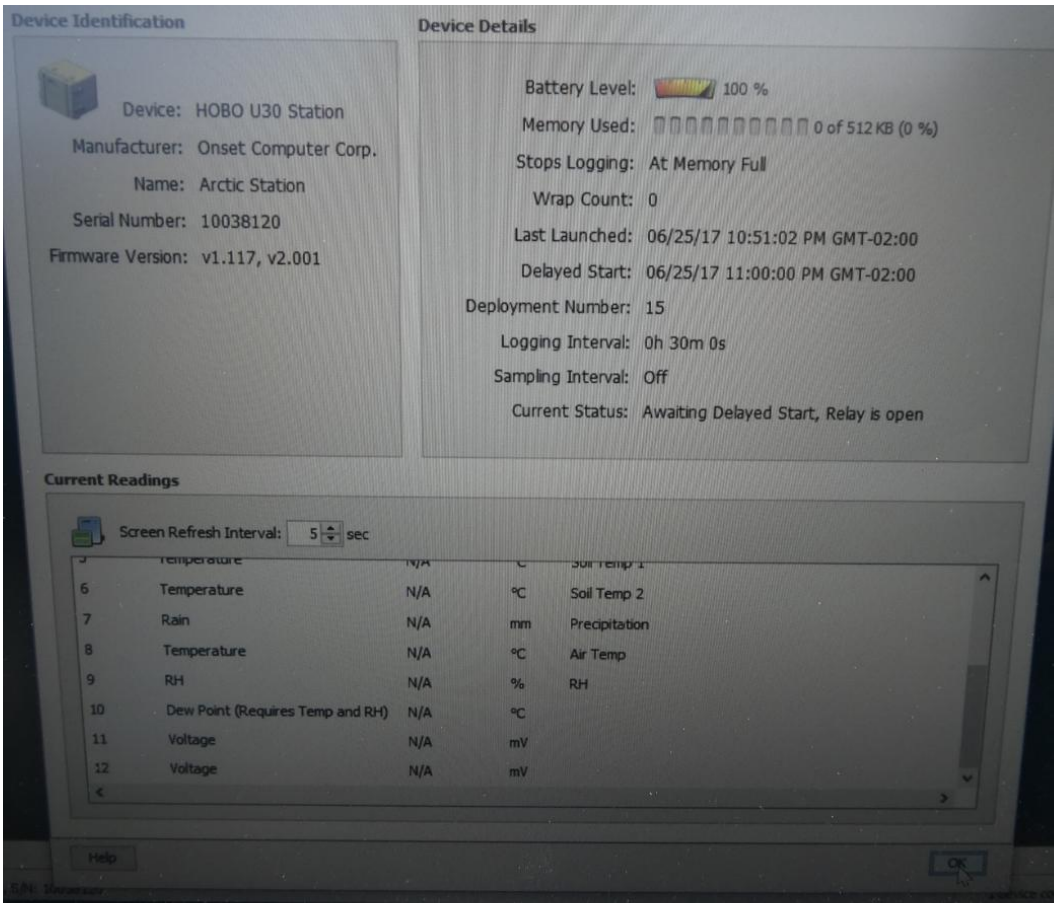




- Export the data to a spreadsheet (.csv file). Select the [Export] icon from the main menu and save the data file.



- Select the icon [Device Status] from the main menu to see actual readings and to check memory and status of the logger. Take a photo or make a screen dump. To free memory space, press **Stop** and Re-launch the logger (make sure all data is saved before you re-launch).



2.4.2 Re-launch HOBO U30 station AWS4 Skarvefjeld

- To launch the station, select [Launch Device]. Go through all settings and make sure they are correct. The station runs Greenlandic summertime (UTC-2). Settings: Log interval: 30 min. Sampling interval: Off (Use the sampling interval only if you have sensors that support measurement averaging). Select delayed start and set the date and time for start of logging (next hour: HH:00)

- After re-launch of the station. Check the Device Status once again to verify that the station is logging or awaiting a delayed start. Check settings and memory status. Make a screen dump

Input of data to the local database

- Copy the retrieved data file to the GeoBasis directory (GeoBasis/AWS4/Original data).
- Open the file and check that the last logged value corresponds to the actual date and time for offloading the station (Remember what time the datalogger runs)

Quick validation of data

To verify that sensors are (and have been) working satisfactorily prepare a worksheet with a copy of data

- Check that the last logged value fits with the actual year, date and time for offloading the datalogger.
- Check that the time series is OK (no missing time steps). Insert a column of correct times and compare with the actual date/time column.
- Make plots of every single parameter for a quick visual inspection of the data. Verify that seasonal variations and the range of data look reasonable.
- If anything looks suspicious or if a sensor has failures or major dropouts, please email a report to the GeoBasis data manager.

2.4.3 Troubleshooting

If you cannot connect to the logger:

- Make sure you have the newest version of HOBOwarePro. The software needs to be the same version or newer than the software used when launching the station.
- Check that you have the right communication settings. In HOBOwarePro press [File] and select [Preferences]. Under [Communications] [Device Types] make sure that USB connection is selected.

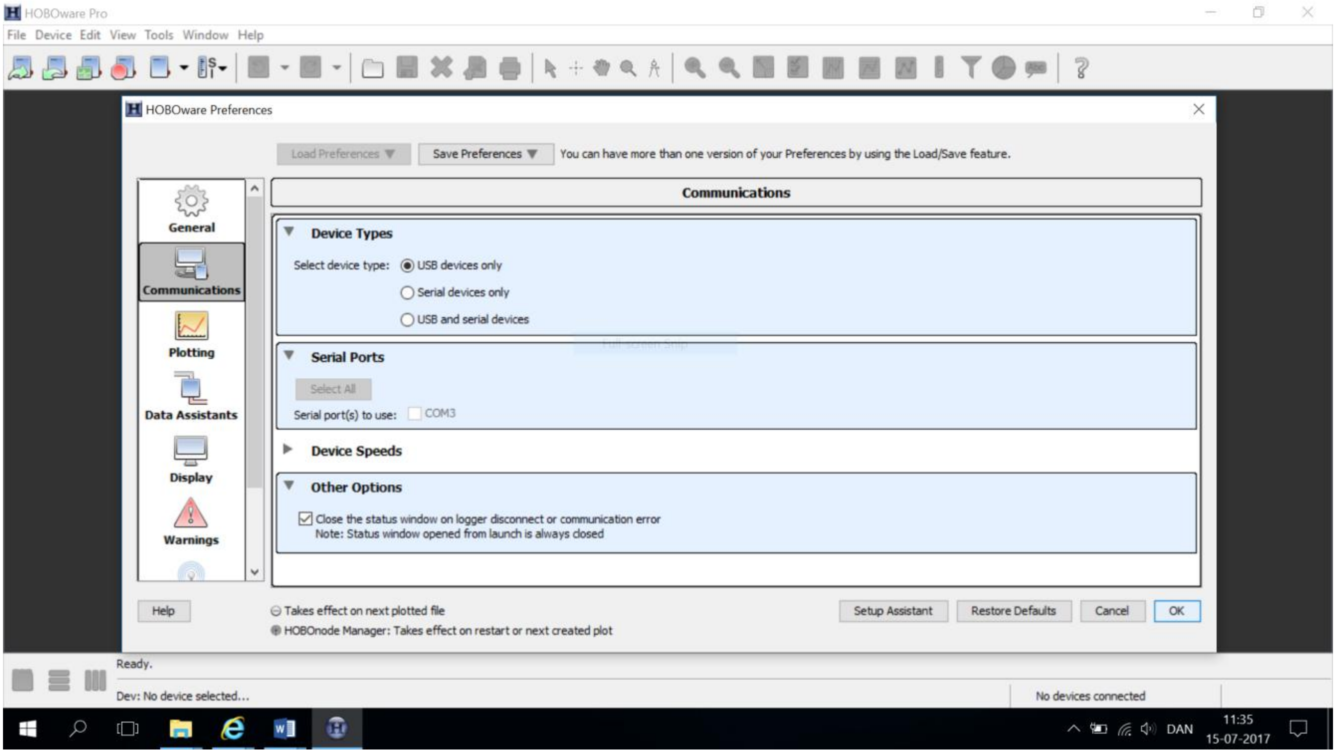


Figure 2.14

2.5 Temperature masts T1, T2, T3, and T4

The masts T1, T2, T3, and T4 measures temperature. Each of the stations consists of a 2-meter-high pole with a double temperature sensor and a logger (HOBO U23-003, Onset). One sensor is placed 2 meters above terrain inside a radiation shield, and the other sensor placed at the ground surface. The masts constitute an altitudinal gradient from sea level to the top of mountain Skarvefjeld (830 m asl).

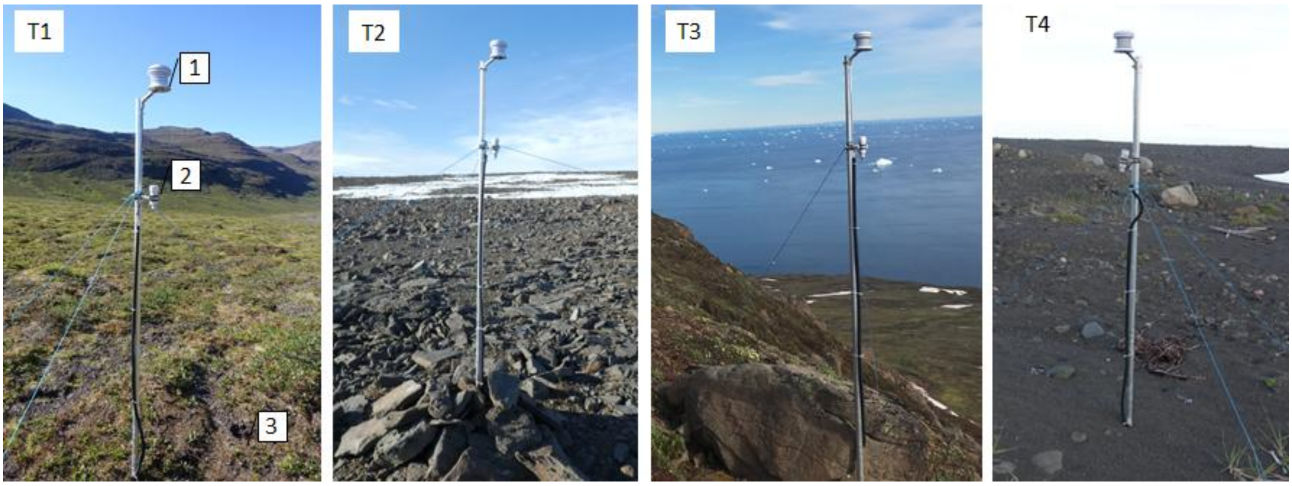


Figure 2.15. T1: Pjeturssons moraine ridge (125 m) (1: Air temperature, 2: datalogger, 3: ground surface temperature) T2: Top of Skarvefjeld (830 m), T3: Skarvefjeld ridge (400 m), T4: Røde Elv delta (1 m).

T1

T1 is located on the top of Pjeturssons moraine ridge. It is a flat open area covered by low vegetation.
Position (decimal degrees): 69.27300°, -53.4795°
Elevation: 125 m a.s.l.
Operation: 2014-
Instrumentation of the mast: -Appendix 1
Power: Battery
Datalogger: HOBO U23-003
Time stamp: UTC-2
Logging interval: 30 min

T2

T2 is located on the top of Skarvefjeld at the western end of the mountain plateau. It is in a flat rocky non-vegetated open area.
Position (decimal degrees): 69.28909 N, 53.43282 W
Elevation: 830 m a.s.l.
Operation: 2014-
Instrumentation of the mast: -Appendix 1
Power: Battery
Datalogger: HOBO U23-003
Time stamp: UTC-2
Logging interval: 30 min

T3

T3 is located on the slope of Skarvefjeld along the southwestern ridge.
Position (decimal degrees): 69.27671°, -53.45710°
Elevation: 400 m a.s.l.
Operation: 2014-
Instrumentation of the mast: -Appendix 1
Power: Battery
Datalogger: HOBO U23-003
Time stamp: UTC-2
Logging interval: 30 min

T4

T4 is located on the eastern side of the river Røde Elv delta near the coast. It stands in dark sandy/gravel material.
Position (decimal degrees): 69.25127°, -53.49897°
Elevation: 1 m a.s.l.
Operation: 2014-
Instrumentation of the mast: -Appendix 1
Power: Battery
Datalogger: HOBO U23-003
Time stamp: UTC-2
Logging interval: 30 min

2.5.1 Offloading data from T1, T2, T3, and T4 (HOBO U23-003)

What to bring

- Optic USB Base Station (Base U4)
- Laptop with HOBOwarePro software (newest edition)
- Multitool
- Camera
- U23-003 Users guide/manual (GeoBasis/Manuals/HOBO U23)
- GeoBasis Manual
- Scotch 33+ (tape)
- GPS

Procedure

- Remove the white UV protection cap from the HOBO logger and place the USB Base Station on top (see figure 2.16)
- Connect the USB end of the cable to the laptop and start HOBOware Pro

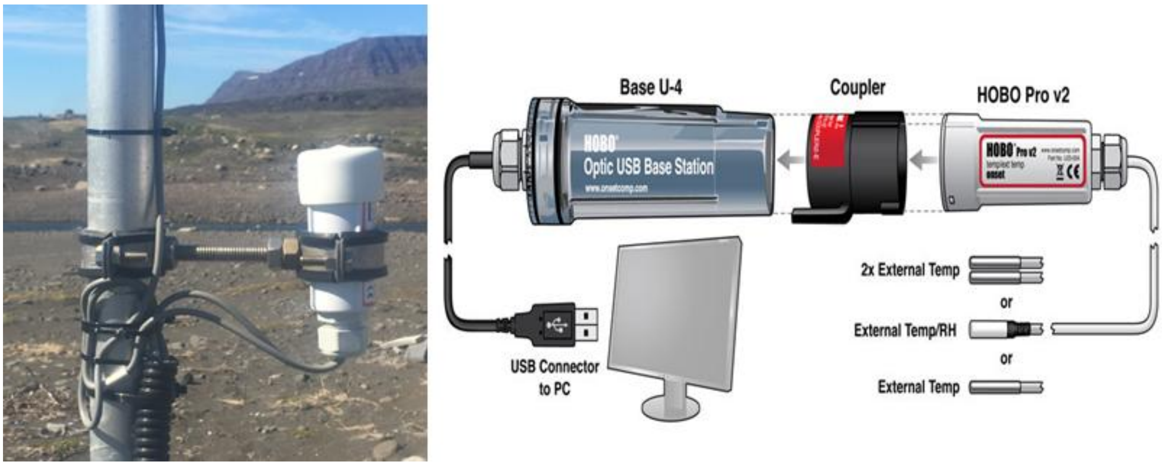


Figure 2.16. HOBO mast T4 in the delta. Looking towards west. Datalogger with protection cap that must be removed when communicating with the logger.

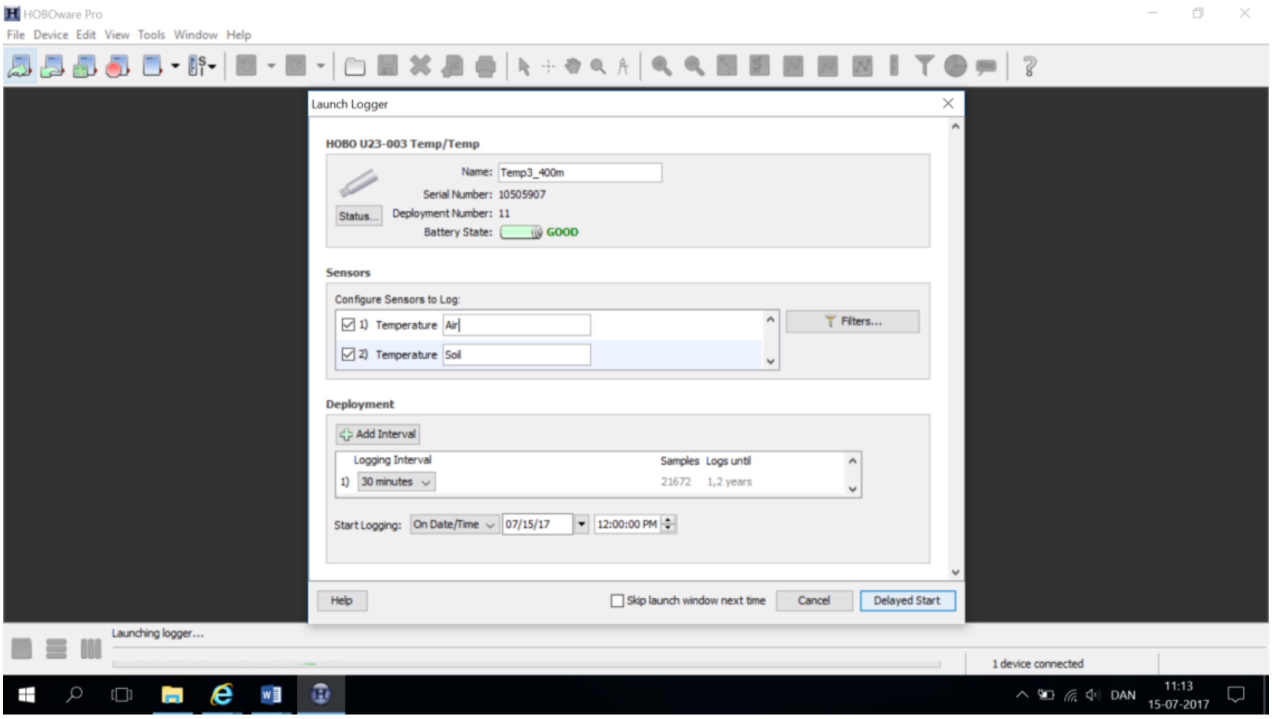
- Follow the procedure given in **section 2.4.1**: Offload data from AWS4 Skarvefjeld

- When you are connected to the station press [Read out device] from the main menu (marked with a red circle). Data can be offloaded without stopping the logger. At least once a year the logger must be stopped and re-lauched to clear the memory and make free space for data storage. (<u>Note: When logging every 30 min this logger holds data for 1.2 years</u>)

- When connected to the logger save data in the folder:
  GeoBasis/Air TemperatureGradient_T1,T2,T3,T4/Original data/YYYY.

2.5.2 Re-launch T1, T2, T3 and T4

1. To launch the station, select [Launch Device]. Go through all settings and make sure they are correct. Settings: Log interval: 30 min. Select delayed start and set the date and time for start of logging (next hour: HH:00). The station runs UTC-2.



- After re-launch of the station. Check the Device Status once again to verify that the station is logging or awaiting delayed start. Check settings and memory status. Make a screen dump.

Input of data to the local database

- Copy the retrieved data file to the GeoBasis directory (GeoBasis/Air temperatureGradient_T1,T2,T3,T4/Original data/YYYY)
- Open the file and check that the last logged value corresponds to the actual date and time for offloading the station.

Quick validation of data

To verify that sensors are (and have been) working satisfactory prepare a worksheet with a copy of data

- Check that the last logged value fits with the actual year, date and time for offloading the datalogger
- Check that the time series is OK (no missing time steps). Insert a column of correct times and compare with the actual date/time column.
- Make plots of every single parameter for a quick visual inspection of the data. Verify that seasonal variations and the range of data look reasonable.
- If anything looks suspicious or if a sensor has failures or major dropouts, please email a report to the GeoBasis data manager.

2.6 General maintenance and visual inspection of the automatic weather stations

There are some general routines for inspection and maintenance whenever you visit the automatic weather stations or other installations. All information and things carried out must be documented by photos and notes in the station log. Each station has a log (Excel worksheet: called Station name_Log_Documentation). Remember to write down date and exact time (specify Time zone (UTC-2) or (UTC-3).

Date	Time	Information	Field staff
11-08-2015	14:30	Station installed by Christian Juncher Jørgensen. Date and Time (GMT-2)	C. J. Jørgensen
12-08-2016	10:30	Data offloaded by Jakob Abermann (ASIAQ). Restart after deleting all data (GMT-3)	J. Abermann
10-06-2017	13:30	Charlotte offloads data and see that the raincollector cable are chewed and broken.	C. Sigsgaard

What to bring

- Silica bags
- Tissue
- Tommestok, folding rule
- Tape + strips
- Bubble level/*vaterpas*
- Soft, clean clothing
- Voltmeter/Multimeter
- Manuals for different sensors
- Maintenance sheet (GeoBasis/AWSXX/Maintenance)

Enclosure: Check that the enclosure is dry inside and change silica bags at least once a year

Cables and wires: Periodically perform a visual inspection. Check that all cables and wires are:

- Free of damage, such as cracks, cuts, and splits.
- Protected in conduit if necessary (exposed cables are prone to being chewed by rodents and should be protected in conduit in locations where rodents are present).
- Ensure that open ends of the conduit point downwards or are closed in a waterproof way. If snow and water can enter the tube/conduit water can be forced into the enclosure or it can freeze inside the tube and squeeze the cable

Sensors:

- Check that radiation sensors are leveled correct. Check with bubble level.
- Carefully wipe off dust/dirt from radiation shields and from radiation sensors (soft and clean clothing)
- At least once a year the station should have a thorough inspection where each sensor is checked according to the maintenance sheet for the station: see GeoBasis/AWS-X/Maintenance/

Datalogger: Verify that the logger is logging data and functioning as you expect.

- The internal battery in the CR1000 data logger must be changed every fifth year. Follow separate manuals: CR1000 manual (GeoBasis/Manuals/Campbell/Cr1000.pdf –care and maintenance)
- HOBO loggers U30: External battery needs to be replaced every 3-5 years. Follow separate manual: (GeoBasis/Manuals/HOBO U30/). The battery is 4 Volt (HRB-U30-S100)
- HOBO loggers U23-003: Internal battery needs to be replaced every 3rd year. Follow separate manual: (GeoBasis/Manuals/HOBO U23/). The battery type is ½ AA 3.6 V Lithium battery.

Power and solar panels:

- Ensure that your solar panel gets full sunlight. Solar panels are extremely sensitive to partial shading. Obstructing even a single cell of the panel will result in significant loss of charging power. Remove snow and dust/bird dropping/dirt from the panels
- Measure battery voltage: directly on batteries placed inside the enclosure –if possible

2.7 Retrieve and send program to the Campbell CR1000 data logger

1. Collect all data from the data logger before installing a new or modified program.

2. Retrieve the old program from the datalogger before installing a new version. Turn on the computer and choose the Campbell software “Loggernet”. Press [Connect] –specify station or data logger type – [Connect] - [Retrieve dld.program] (Figure 2.17).

3. Save the retrieved program into a folder named ‘Program’ and save in GeoBasis/XX (ex. AWS3/Program/folder named actual date and time for retrieval yyyymmdd.

4. To upload a new program, press [Send], browse to the new program. Ensure that the program works by offloading data after one hour and check values.

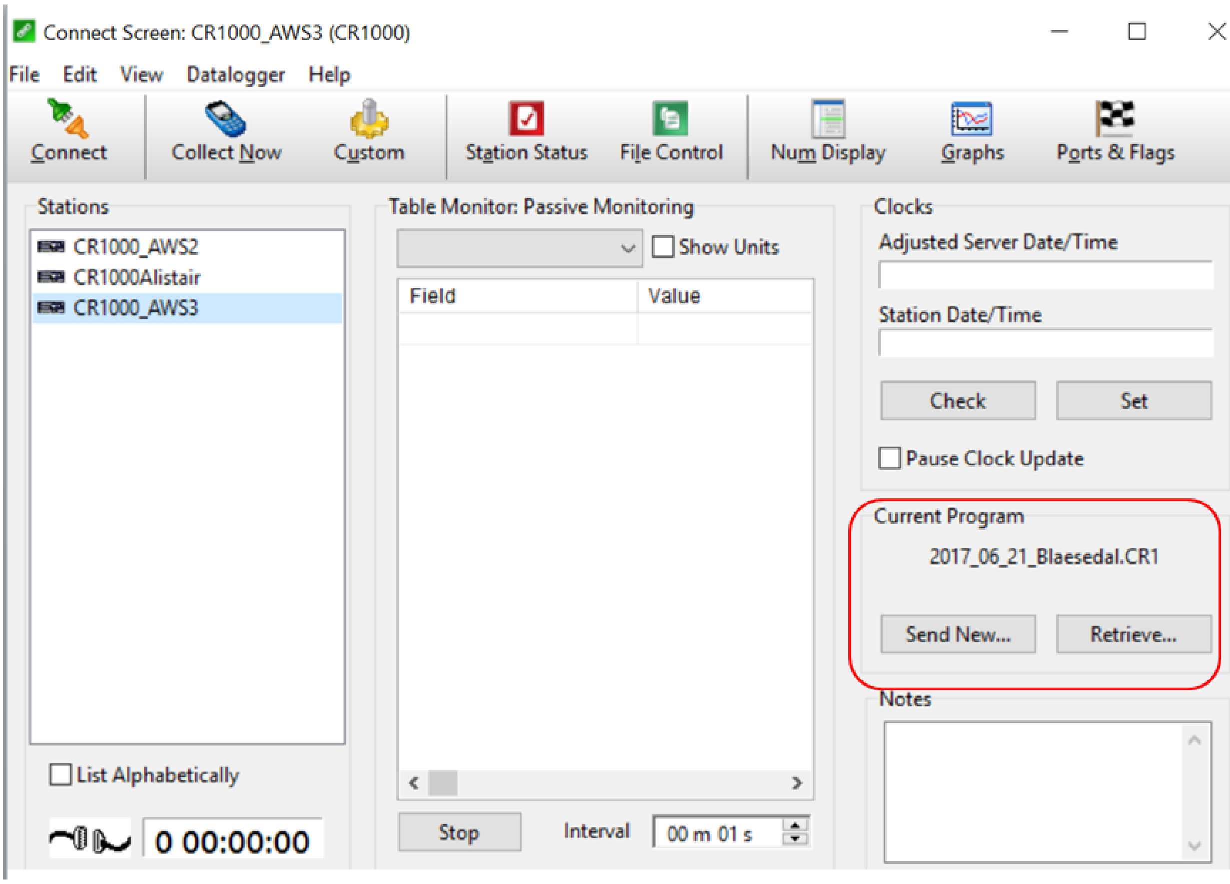


Figure 2.17. Loggernet Connect screen.

3 Gas flux monitoring

3.1 Introduction

The land-atmosphere exchange of greenhouse gases and energy in the Arctic is a crucial process in the context of climate change. Arctic ecosystems contain large stocks of soil organic carbon; these stocks are a result of net carbon accumulation during thousands of years due to cold and poorly aerated soil conditions inhibiting decomposition rates. Changes in climate, including increasing temperatures and altered hydrology, will result in significant changes in the CO_2 energy fluxes, which are likely to pose a strong feedback effect on global warming. Long-term monitoring of greenhouse gas and energy exchange is therefore of the uttermost importance.

Across the GeoBasis monitoring sites (Zackenberg, Nuuk, Disko) eddy covariance stations measure fluxes on a landscape scale, where fluxes are calculated based on the covariance between vertical wind speed and scalar of interest (i.e. CO_2, CH_4 H2O and temperature). The acquired data from these stations can thus be used to calculate carbon and energy budgets, as well as to study the variation in fluxes under various meteorological conditions.

In Disko, eddy covariance measurements have been conducted in Østerlien since 2013. The eddy covariance mast (EC1) is located next to the automatic weather station AWS2 where standard meteorological variables including net radiation and soil heat flux are being measured allowing for complete assessment of the energy budgets. To describe the inter annual variability of the seasonal carbon balance Net Ecosystem Exchange (NEE) carbon dioxide (CO_2) are being measured by use of eddy covariance technique. The stable power supply at this site allows measurements to run year-round.
Over the past years the instrumentation, setup, data logging, and processing have been standardized across GEM stations to be aligned with ICOS standards. **ICOS** is a European-wide greenhouse gas research infrastructure established with the purpose of providing the highest quality flux data. Disko received the label: ICOS Associated Ecosystem Station in 2021.

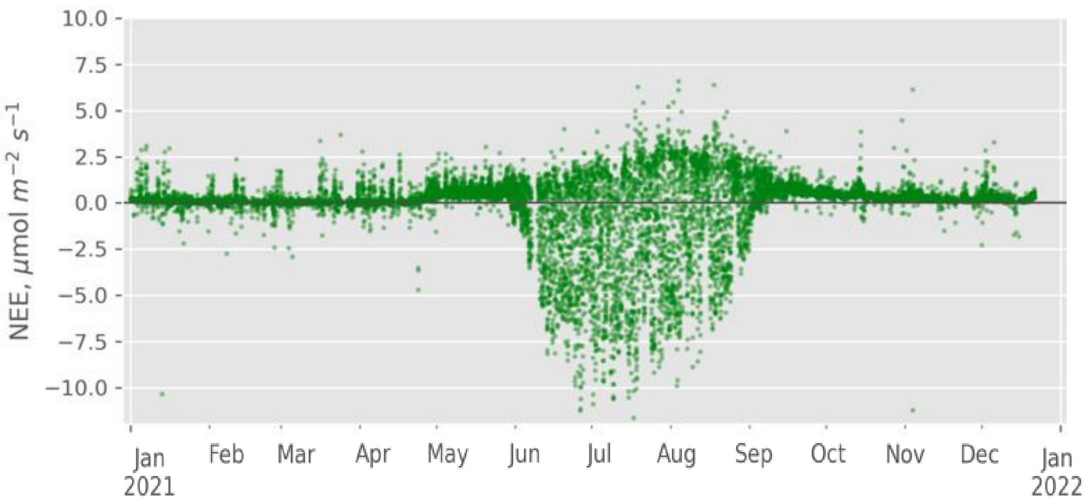


Figure 3.1. Temporal variation of diurnal net ecosystem exchange (NEE) measured at Østerlien. NEE refers to the sum of all CO_2 exchange processes, including photosynthetic CO_2 uptake by plants, plant respiration and microbial decomposition. Fluxes directed from the land surface to the atmosphere are positive (i.e. a net release of CO_2), while fluxes directed from the atmosphere to the land surface are negative (i.e. net uptake of CO_2).

Where to find data in the GEM Database

Program: GeoBasisDisko, **Program group**: Flux monitoring, **Group-element**: Gas flux (EC1) or Gasflux (EC1)-Smart

- GeoBasisDisko/Flux monitoring/Gas flux (EC1) data from 2013-2019
- GeoBasisDisko/Flux monitoring/Gas flux (EC1-smart) data from 2019-present

3.2 Gas flux monitoring in Østerlien

The Eddy mast (EC-1) is part of the Automatic Weather Station AWS2 in Østerlien (see section 2.2 for more information about AWS2 and Østerlien). The eddy covariance system (Figure 3.2) comprises a 3D sonic anemometer (model HS-50 by Gill Instruments Ltd.) a Gill interface unit, an enclosed CO_2/H_2O gas analyzer (model LI-7200RS by LICOR Environment) connected to its Analyzer Interface Unit (AIU, model LI-7550) as well as a Flow module (Licor 7200-101), enclosed in a white box.

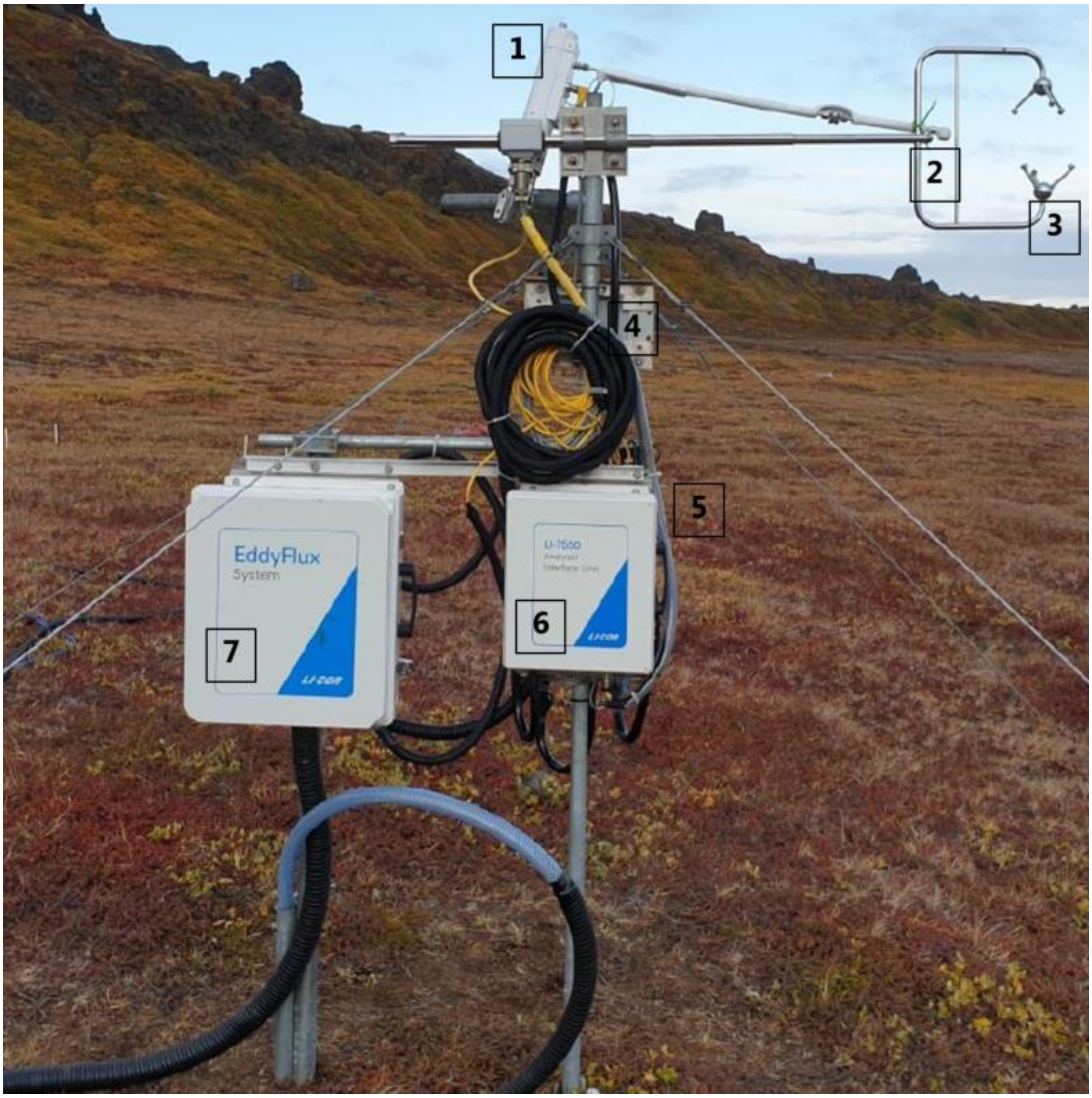


Figure 3.2. The Eddy covariance mast (EC1) in Østerlien. 1) Licor 7200RS, 2) Air intake 0.25'' (inner diameter 0.21''=5,334 mm, 3) GILL 3D Sonic anemometer HS50, 4) GILL Interface Unit, 5) Flow module Li-7200-101, 6) Analyzer Interface Unit (AIU) Li-7550, 7) EddyFlux-Smart Flux2.

The LI-7200 is an infrared gas analyzer with an enclosed sampling cell. It is equipped with a 1-m heated air intake tube, terminated by an intake cap and filter to prevent rain and dust from entering the analyzer optical path. A flow module keeps a constant flow of air into the gas analyzer by an average flow rate of 10 liters per minute. A pressure sensor is located within the AIU box. There are fine-wire thermocouples that measure incoming, and outgoing air temperature located in the air inlet and outlet ports of the LI-7200 (please always refrain from inserting long objects such as narrow tubing into the Inlet and/or Outlet ports to avoid damaging the thermocouples). Cell temperature and total pressure are logged by the AIU (Figure 3.4).

All power cables are plugged in the Power supply complex, a few meters away (Figure 2.4).

Figure 3.3. Inside the EddyFlux box the SmartFlux2 module is found (#7 in Figure 3.2).

Figure 3.4 Flow module LI-7200-101 (inside Box 5 in Figure 3.2) to the left, and Licor Analyzer Interface Unit AIU LI-7550 (inside Box 6 in Fiugure 3.2) to the right.

3.2.1 Offloading data from the EC tower (PC)

The data from the eddy covariance mast is logged continuously to USB sticks and to a PC. Data from AWS2 and EC1 is automatically transmitted to a server at IGN and can be remotely accessed.

I:\SCIENCE-CENPERM-DATA01\AS_SMARTFLUX_UPLOAD

2022-02-24T093000_AIU-2008.ghg	24-02-2022 14:16	GHG File	2.971 KB
2022-02-24T093000_AIU-2008.zip	24-02-2022 14:16	Compressed (zipp...	14 KB
2022-02-24T100000_AIU-2008.ghg	24-02-2022 14:46	GHG File	2.986 KB
2022-02-24T100000_AIU-2008.zip	24-02-2022 14:46	Compressed (zipp...	14 KB
2022-02-24T103000_AIU-2008.ghg	24-02-2022 15:16	GHG File	3.018 KB
2022-02-24T103000_AIU-2008.zip	24-02-2022 15:16	Compressed (zipp...	14 KB

3.2.2 Offloading data from EC tower (USB)

Data is saved directly to a USB placed in the LI-7550 Analyzer Interface Unit and a USB in the SmartFlux box (Figure 3.6). The 2 USB needs to be replaced and offloaded once a month.

Procedure

1. Simply press [eject] on the grey button under the “USB logging”. When the red LED stops flashing it is safe to remove the USB

After removing the USB, replace it with a formatted Licor USB stick. When the formatted USB is inserted keep an eye on the LED light until the light indicates logging. It may take a short time (within seconds) while tables are created. When light starts to blink rapidly, it indicates that the system has started logging. If logging does not start after a while, then the LED will indicate an error (Figure 3.5). In case of error blinking, try to eject and re-insert. If this does not work the system/station may need to be restarted (follow section 3.3 to power off system and section 3.4 to power on system)

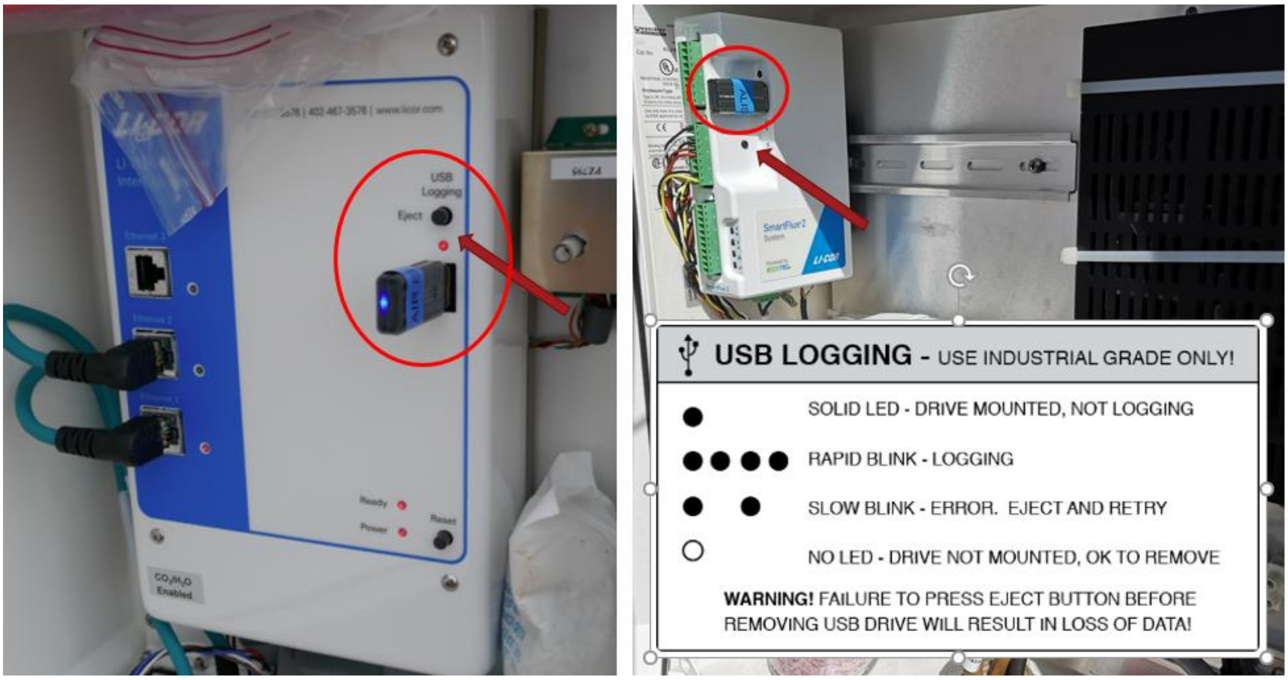
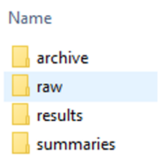


Figure 3.5 Position of the USB in the Analyzer Interface Unit LI-7550 (left) and in the SmartFlux box (right). Included is the USB logging LED indicators.

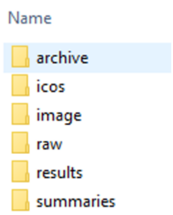
Copy all data from the USB to

GeoBasis/EC1/Original data/SmartFluxUSB or
GeoBasis/EC1/Original data/Li7550USB

Data structure on the USB in Li7550

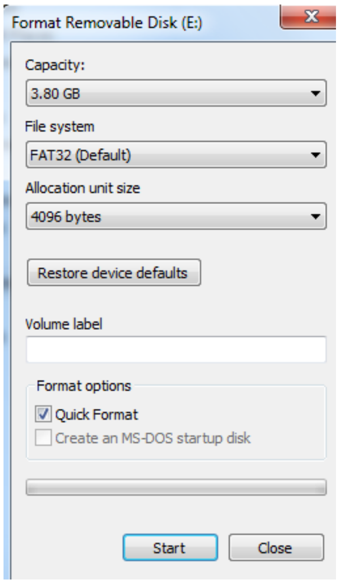


Data structure on the USB in the SmartFlux



3.2.3 Formatting a USB

We use the Licor industrial rated USB

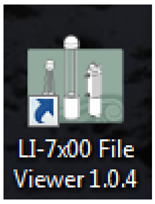


- Right click on the USB-drive and press [Format]. A new window will appear where you have to specify the format options. Use the 'File system' FAT32 and leave all other options as default values.

- Press [Start]. Click [OK] to the warning and [OK] when the format has finished.

Quick validation of data

To verify that sensors are working satisfactorily inspect the data visually.



- View the original files from the Eddy Covariance tower (EC1) in the file viewer program "Li 7x00 File viewer". Press [+] in the lower left corner of the screen to add files. Mark the files you want to view. When files are loaded you can double click on each variable to see a chart

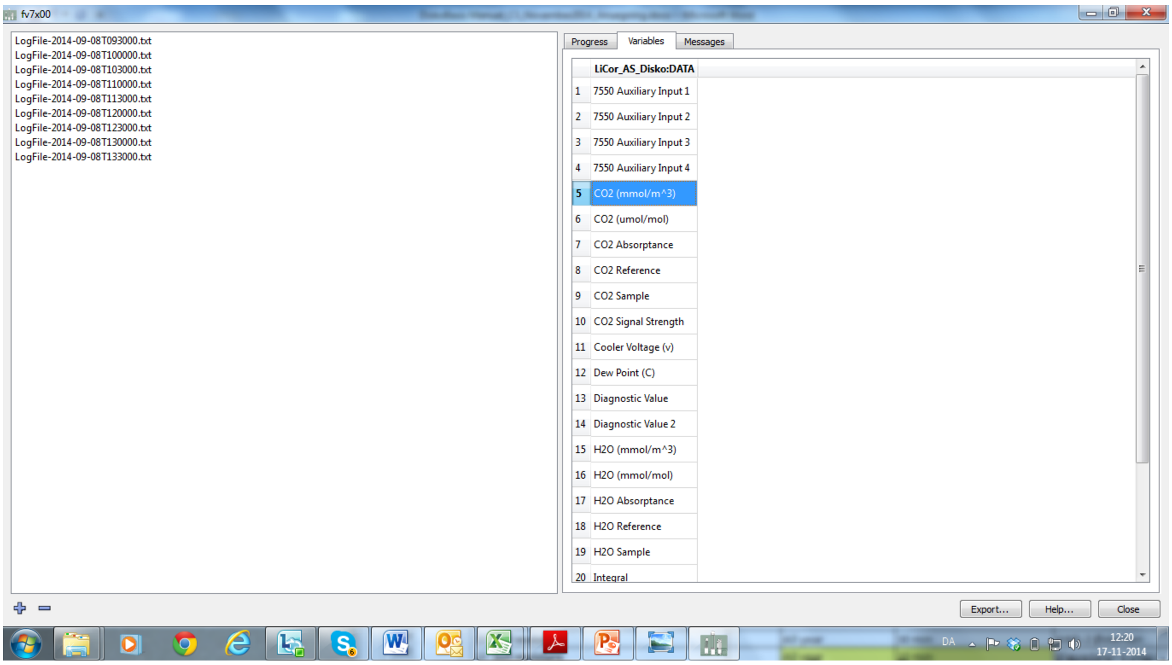


Figure 3.6. Screen from the Li7x00 File Viewer software.

- Check that variation in parameters seems okay. For an idea of the ranges for each parameter, please refer to the sheet: GeoBasis/EC-1/Østerlien/Data ranges. If anything looks suspicious or if a sensor has failures or major dropouts, please report to Data manager: Charlotte Sigsgaard or Rasmus Jensen.

3.3 Power off the station

3.3.1 Power off the Licor analyzer and the SmartFlux:

If you need to power off the EC1-station in Østerlien do the following: Unplug the power from the SmartFlux (Figure 3.7) and unplug the power to the Licor by unplugging the power switch in the Power box (Figure 3.7 right). It is important to 'power off' both when closing down the system.

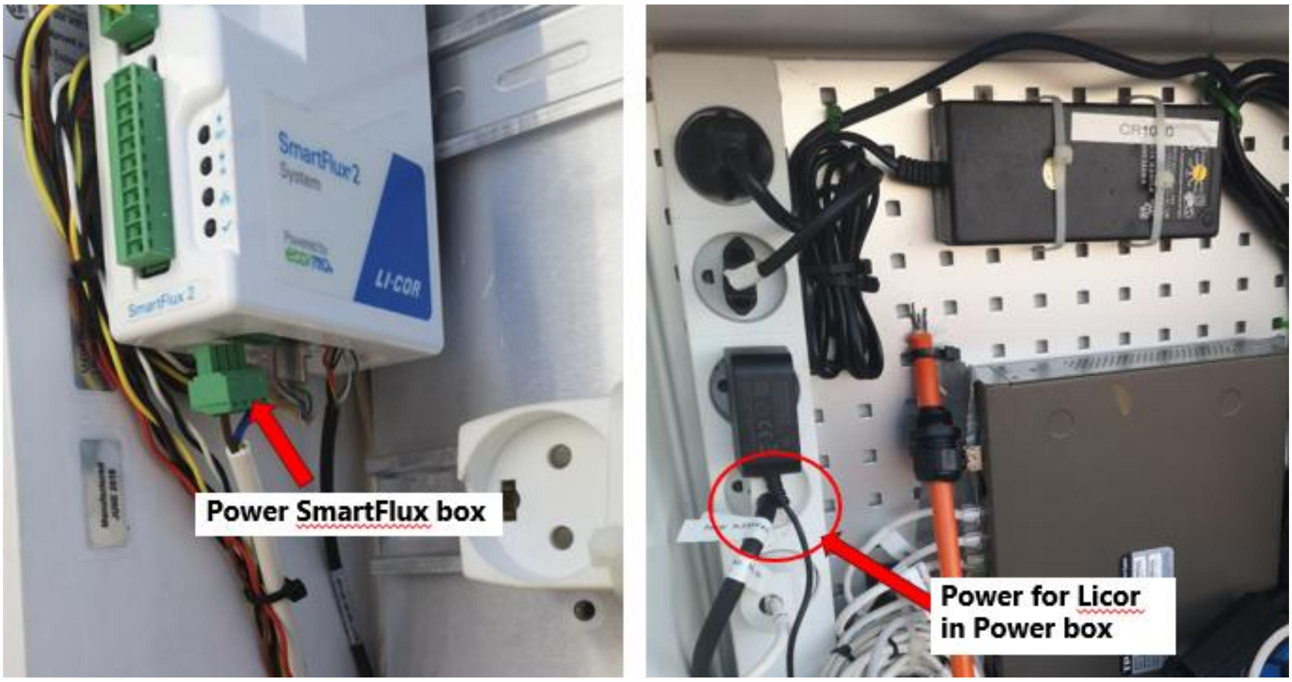


Figure 3.7. Power connection in the lower panel on the SmartFlux box. Power switch to Licor analyzer is found in the Power box.

3.3.2 Power off the GILL Sonic anemometer

The GILL anemometer is powered by the Licor analyzer. To power off the Gill you will have to power off the Licor.

3.4 Resuming data logging after a break

If the system has been switched off for maintenance or due to power failures, make sure that data logging resumes when the system is powered back on. To power on the system –reconnect the power plugs in the sockets. Check the Licor software on the computer in the garage. If it does not start as soon as the system is powered on, you can start the Licor software and connect to the Licor instrument. Settings are kept as they were. However, please check the following:

- Check the logging status and check the USB Free Space
- Check that the SmartFlux Status is OK

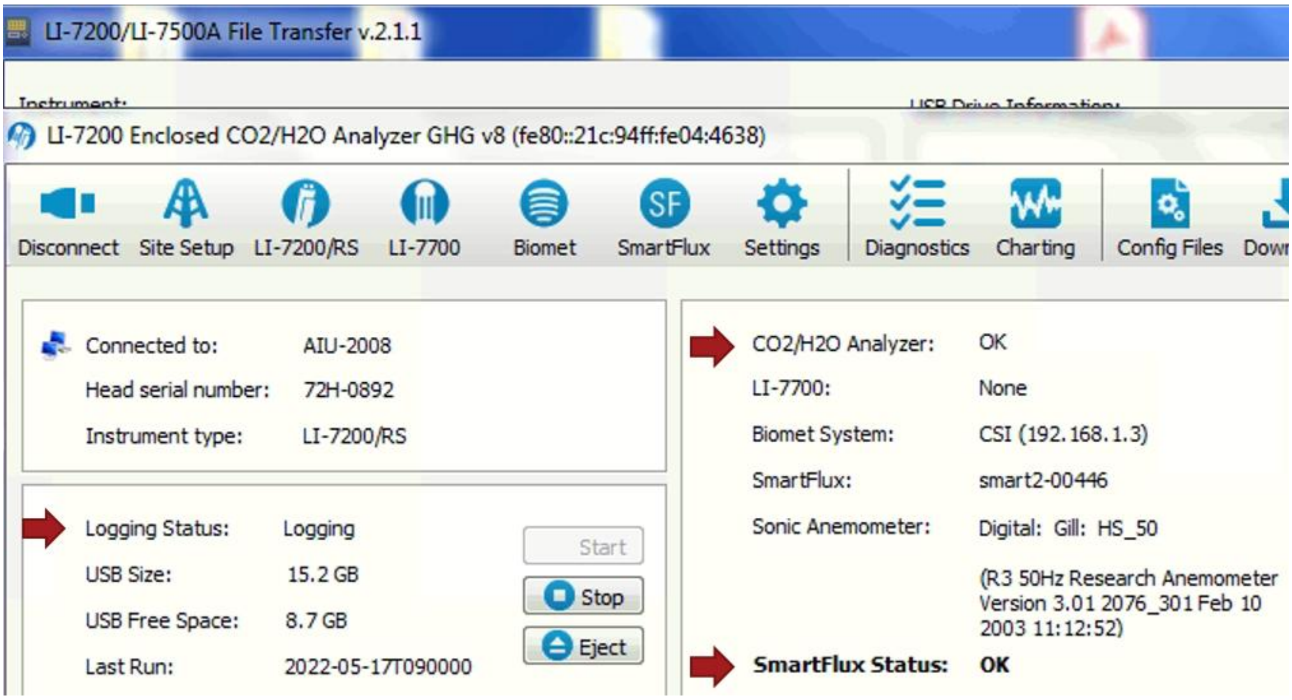


Figure 3.9

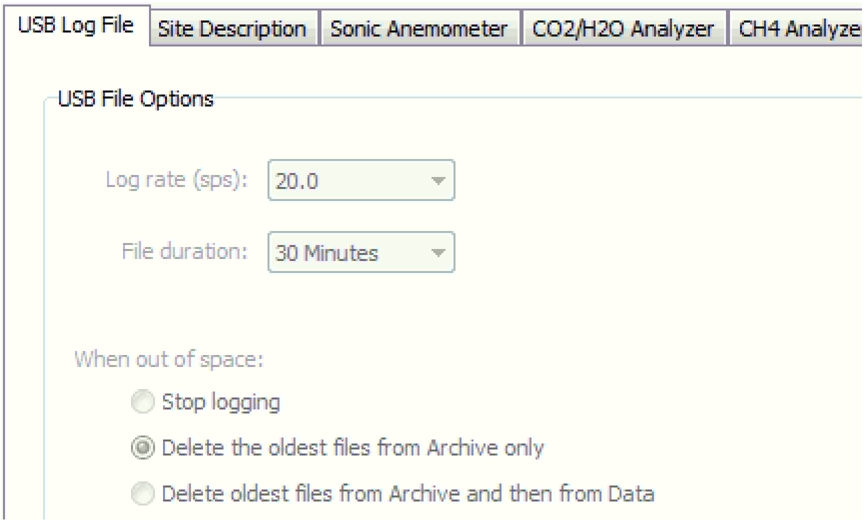
3.4.1 Automatic data transfer

Data are continuously transferred via internet connection.

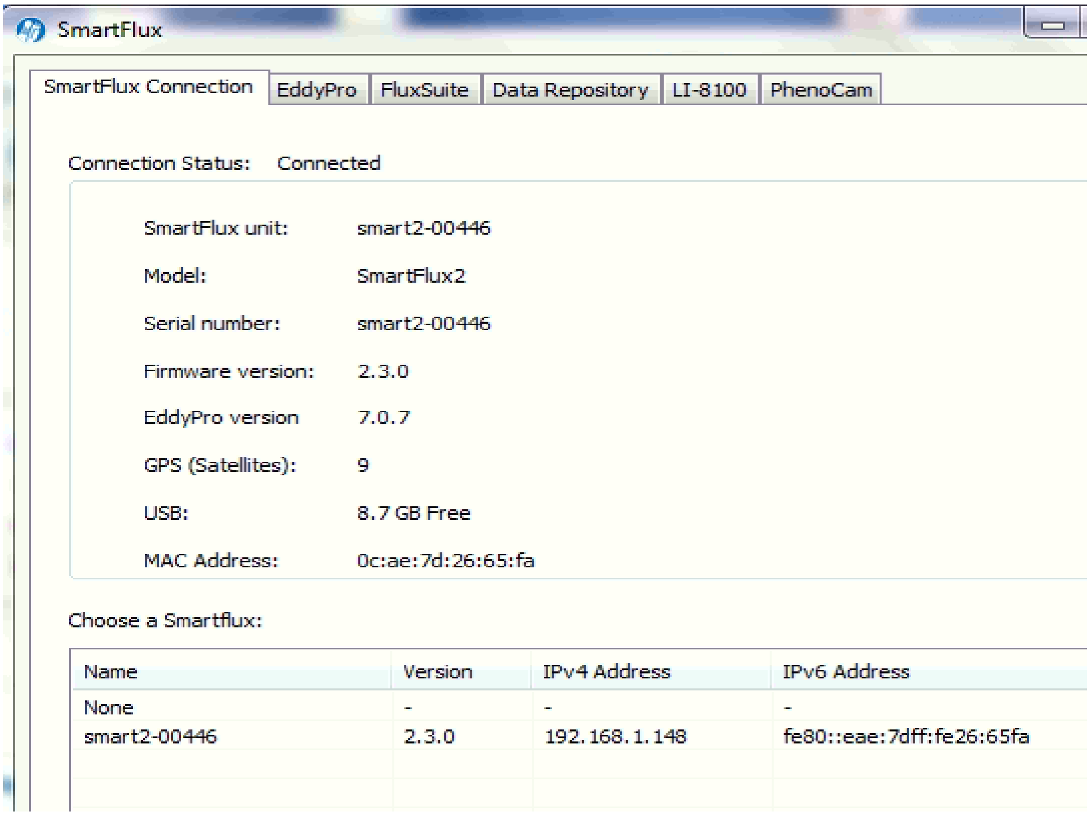
3.4.2 USB logging

You can see the logging status in the front panel of the software. Select [Site setup] from the Licor software main menu to ensure that the settings are correct. Select [USB Log File] from the drop-down menu.

- Log rate: 20 Hz
- File Duration: 30 min
- When out of space: Delete the oldest files from Archive only



- In addition to the USB Status on the front panel in the software also check the SmartFlux sensor USB. This is done in the SmartFlux dropdown menu looking at the sub menu ‘SmartFlux Connection’. The Smart Flux fills up the USB faster than the USB in the Licor-7550.



Settings

- The housing temperature is kept at 30°C since we have enough power there is no reason to change it for the winter.
- The time on the Licor follow UTC-3 all year round.

3.5 Connecting to the instrument

The infrared gas analyzers (IRGA) need regular check and maintenance. To check that the instrument is functioning properly, one needs to have access to the analyzer via direct connection with a computer. The analyzer interface unit in Østerlien is connected to the computer in the garage. Thus, the analyzer readings can be checked at any time in the main window of the LICOR software (the computer in the garage can be accessed via AnyDesk).

Procedure

1. Open the LICOR software on your computer. Wait for the analyzer to appear. Select the instrument and press connect.

The main window shows a summary of the instrument status, and a real-time display of the variables logged (Figure 3.10). You can change the displayed variables by a right-click on the numbers and then select from a list of all logged variables. **Auxiliary Input 1** refers to the horizontal wind component *u* in m s^{-1}; **Auxiliary Input 2** is the horizontal wind component *v* in m s^{-1}; **Auxiliary Input 3** is the vertical wind component *w* in m s^{-1}; **Auxiliary Input 4** is the sonic temperature in Celsius degrees.

Figure 3.10. Licor main window

3.6. Maintenance

Please read through Section 5 in the LI-7200RS manual where detailed guidelines for routine maintenance of the gas analyzers are provided. Read the separate manual made for EC1 in Østerlien: All manuals for this station are found in the folder: GeoBasis/Manuals/Licor or GeoBasis/Manuals/GILL.

In summary:

Every few days to weekly:

- Check readings of CO_2 and H_20 and signal strength (3.6.1)

Once a month:

- ZERO and SPAN check of the Licor (3.6.2)

Once a year:

- Replace internal chemicals (3.6.4)
- Cleaning the intake cap and screen (3.6.5)
- Change particulate filter in the heated air intake (3.6.7)
- Inspect cables, tubes and conduits
- Clean mirrors and optical path (3.6.6)

After rain events:

- Check the water trap in front of the flow module

After changes in the set-up and mounting

- Measure distances between the sensors and the ground surface before and after any changes to the mast set-up
- Copy the configuration file from the Licor analyzer

Every 5th year

- Change rubber tubing

3.6.1 Check the readings and signal strength from the Licor analyzer

- Check the readings of the instrument via the LICOR interface software. In Østerlien, this is done on the computer in the garage. For an idea of the ranges for each parameter, please refer to the sheet: GeoBasis/EC-1/Østerlien/Data ranges. If anything looks suspicious or if a sensor has failures or major dropouts, please report to Data manager: Charlotte Sigsgaard or Rasmus Jensen.

3.6.2 ZERO and SPAN check of the Licor

- Perform a zero check (CO_2, H_2O) and a span check (CO_2) of the LI-7200 RS. Calibration gases are stored in the wire enclosure outside the lab building. Follow instructions in the Licor 7200 RS Instruction Manual. Exact values for concentrations are given in the gas calibration sheets

Figure 3.11. Calibration gas bottles (from 2020) and flow regulator.

3.6.3 Calibration of the Licor (ZERO and SPAN)

- Follow the procedure given in the Licor 7200 RS Instruction Manual.

3.6.4 Replace internal chemicals

Preferably in spring or at the beginning of the summer: replace internal chemicals in the Licor analyzer. Perform a zero and span check of the analyzer 24 hours after changing the internal chemicals. Perform a calibration of the analyzer if the zero and span checks reveal a drift in gas concentration readings.

3.6.5 Change or clean air intake cap and screen

- Follow the procedure given in the Licor 7200 manual and in the separate sheet/manual: GeoBasis/Manuals/Licor/7200_Intake_Cap_-_Dust_Filter_Install_Guide.pdf. If you need to change the filter: find a spare part in the GeoBasis storage room. Unmount the intake from the LI-7200 (see Manual for detailed directions for unmounting the intake tube). You will need a screwdriver to extract the filter from the intake cap. Be mindful of keeping the cap intact. Replace by a new or clean filter and remount the cap. The dirty filter should be cleaned after removal and stored for future use.

3.6.6 Clean the optical windows and optical path of the Licor

- Refer to the manual for detailed directions. For the LI-7200, Use the diluted ethanol to clean the path. A cleaning of the optical path should be followed by a zero and span check and by a calibration of the instrument if the checks reveal a drift in readings.

3.6.7 Change particulate filter in the heated air intake

- Refer to the manual: 7200_InstallGuide_Heated_Intake_Tube_15538.pdf

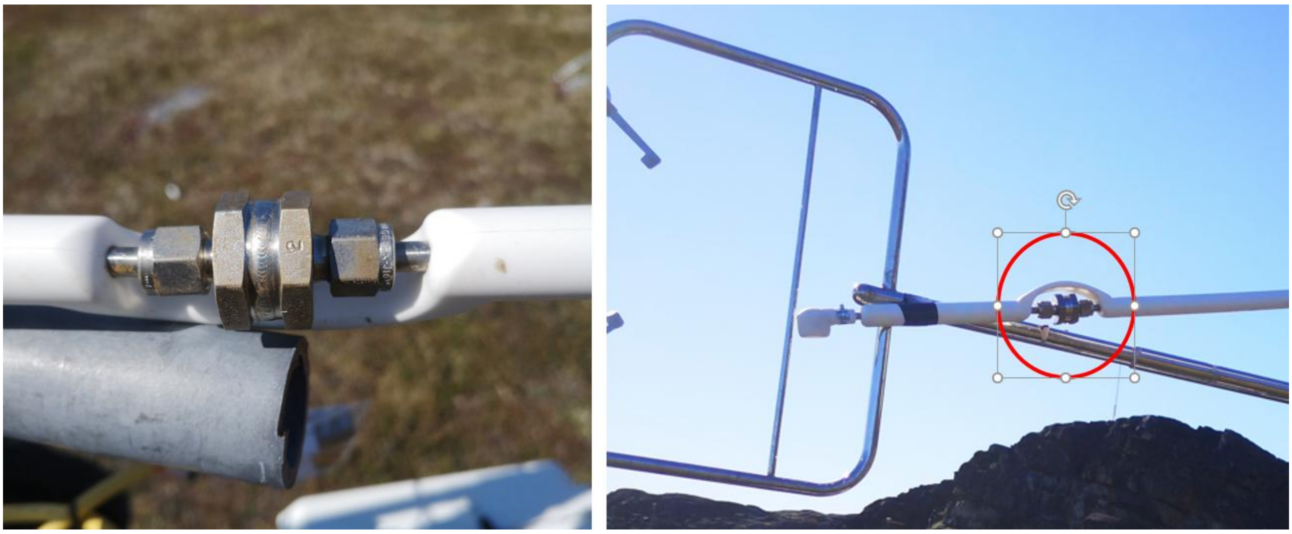


Figure 3.11. Particulate filter in the heated tubing.

3.6.8 Documentation (Photos and Logbook)

Keeping the logbook up to date is essential for keeping track of changes, ensuring a well-functioning system and helping the interpretation of the fluxes.

- Please always note when visiting/changing anything on the mast. There is a paper logbook and pencil in the interface unit box (LI-7550). Please note any visit. Take photos of the book to update the electronic log following your visit. The electronic logs are found at: GeoBasis/EC1/Logbook

- All manipulations and changes should be logged in the Maintenance sheet along with date and time (local summer or winter time or logging time), and the person who performed the changes. Please also note anything that could affect the flux measurements or lead to peculiar readings (e.g. animal or human disturbance).

- Photos are valuable and helpful additional documentation to any change, manipulation, observations or calibration. Whenever possible, document the changes and status of the set-up with photos.

4. Snow, ice and permafrost monitoring

4.1 Introduction:

Snow depth and snow cover are among the key parameters in the control of climate and ecosystem processes characterizing the Arctic. The seasonal and spatial variation in snow cover also significantly affects distribution of vegetation and length of the growing season, which indirectly affects the production of greenhouse gases such as carbon dioxide (CO_2) and methane (CH_4). Snow has a major impact on the below snow environment due to the insulation properties providing stable thermal conditions. However, the winter snow cover also has a direct impact on ecosystem dynamics and processes observed during the snow-free growing season. Snow also plays a major role in the hydrological system since a large part of the precipitation falls as snow.

Local intro:

Around Arctic Station snow can be observed during any month of the year. In general, a continuous snow cover is established in October and melts in May/June. However, large annual variations are observed. At the weather station AWS2 (where snow depth is measured on a continuous basis) the snow depth is often very low due to re-distribution of the snow by the wind. Snow may also disappear during winter due to periods with positive temperatures -Føhn situations or even rain events (can take place at any time during winter).

Parameters to be measured

- Snow cover (Østerlien)
- Snow depth (Østerlien and Blæsedalen)
- Snow density (Østerlien and Blæsedalen)
- Ice cover DiskoBay (Arctic Station Monitoring)

Where to find data in the GEM Database

Program/**Program group**/**Group-element**:

GeoBasis Disko/Snow/AWS2-SnowDepth

GeoBasis Disko/Snow/AWS2-SnowAirTemperature

GeoBasis Disko/Snow/SnowDensity (contact GeoBasisDisko DB-manager)

GeoBasis Disko/Snow/SnowTemperature (contact GeoBasisDisko DB manager)

GeoBasis Disko/Snow/SnowDepth (contact GeoBasisDisko DB manager)

4.2 Snow cover and snow depletion

Automatic daily photo monitoring is used to follow snow cover build-up and depletion throughout the year in Østerlien. Digital images are captured from a camera in a waterproof box. Photos are available from the data manager.

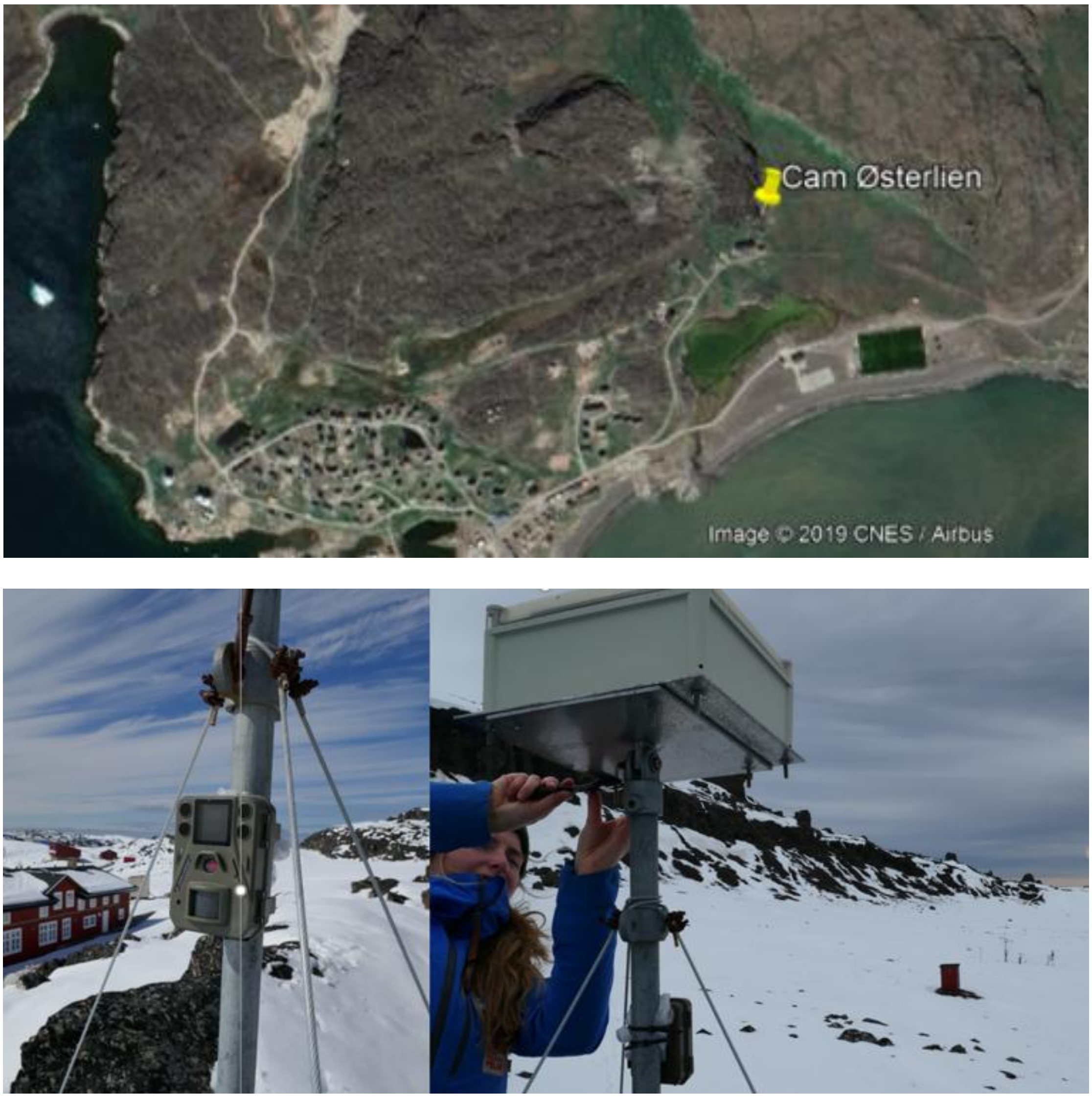


Figure 4.1 Automatic camera installed behind Arctic Station. The camera points towards east, looking at Østerlien.

Location Cam1-Østerlien

The camera is located on the bedrock behind/just north of Arctic Station. The camera is looking east and the ‘field of view’ covers the installations in Østerlien

Position (decimal degrees): 69.253646°, -53.516639°

Elevation: 28 m a.s.l.

Camera has been operating on and off since: 2012-

Camera: CanonEO5 from 2012 and BolyGuard from August 2022

26-09-2012 06-10-2012 19-11-2012

Figure 4.2 Photos from Cam-1 Østerlien

4.2.1 Offloading camera

Equipment to be used

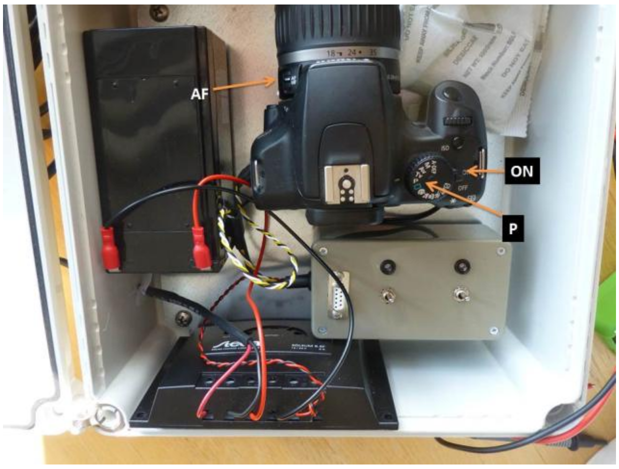
- Big flathead screwdriver
- Replacement SD-card
- Spare silica bag and tissue
- Camera Manuals (GeoBasis/Manuals/AutomaticCamera)

Canon camera in the Box

1. Undo the Fibox plastic screws with the screwdriver and carefully open/remove the lid (watch out for cables attached to solar panel in the lid and battery in the box).
2. Take the SD card out of the camera and place the new formatted SD card in the slot. <u>Be careful to close the card holder door, otherwise the camera will not take photos</u>
3. Test the camera by firmly shifting one of the control switches on the trigger box (maybe you must wait a few seconds or try 2 times) to activate the camera. When activated –press the trigger button on the camera and take a photo
4. Before you close the box make sure that the camera settings are right (section 4.2.2) and check that there is a desiccant bag (silica gel) in the box. Change if necessary. Pay attention to all cables when you close the lid of the box. Make sure that water can drain from the screw holes –otherwise the lid may open when water trapped in the hole freezes and expands
5. Check that the window in front of the lens is clear
6. Please back-up the photos before SD-card is deleted/formatted. Local destination folder: GeoBasis/Automatic Photomonitoring/Østerllien/Cam1

4.2.2 Camera settings Canon camera

Follow the Canon camera Manuals: Time settings on the camera are set for UTC-2. Select [P] on the program wheel and [auto] for ISO, aperture and shutter speed. File format is set to RAW.



4.2.3 Camera settings Bolyguard camera

Follow the BolyGuard manual: Set date and time in the camera menu. Time settings on the camera are set for UTC-2. The camera trigger system is set for 3 images per day (every 8 hours). 5:00, 13:00, 21:00.

4.3 Automatic registration of sea ice cover (Arctic Station camera)

In 2015, a digital camera was installed at the mountain Lyngmarksfjeldet to improve sea ice registration. The aim was to follow sea ice cover formation and break up in the Disko Bay area outside Qeqertarsuaq daily. It is a supplement to the visual observations carried out by staff at Arctic Station since 1991. After 2022, the photo-monitoring from Lyngmark became part of the GeoBasis.

Figure 4.3 Position of the camera at top of Lyngmarksfjeldet and the camera set-up.

Location Cam2-Lyngmarksfjeld

The camera is located on a solar panel rag on top of Lyngmarksfjeldet. The camera is facing south and covers a part of the Disko Bay (see photos from the camera figure 3.6)
Position (decimal degrees): 69.27139, 53.54667
Elevation: 385 m asl
Camera has been operating on and off from: 2015
Camera model: Canon EOS 6D, replaced by Bolyguard compact in August 2022, replaced by Hyperfire Camera in September 2023

Figure 4.4 Photos captured by the camera at Lyngmarksfjeldet 19-04-2015 and 19-05-2015

4.4 Snow depth

At the Automatic weather station AWS2 (see section 2.2) snow depth is logged continuously at one point. To validate these readings, the actual snow depth must be measured a few times during the snow season. Finally, snow depth is measured manually just north of the scientific leader's house (Figure 4.5)

4.4.1 Manual snow depth measurements

Equipment to be used

- Field chart and pen
- Snow probe/active layer probe
- Folding rule

Procedure at the snow sensor

1. Measure snow depth below the sonic sensor at AWS2. Remember to note date and time for the measurement. Be careful not to walk right under the sensor

2. Measure distance from the bottom of the SR50 sonic sensor to the snow surface.

4.4.2 Snow depth measurements using MagnaProbe

To extend the number of point measurements for a better spatial coverage of the snow, snow depths are measured manually by probing along transects in Østerlien using a snow depth probe combined with a GPS and a datalogger (MagnaProbe from SNOW and HYDRO).

Location

Snow depths are measured along two transects; one in Østerlien and one in the area north of the scientific leader's house (Figure 4.5).

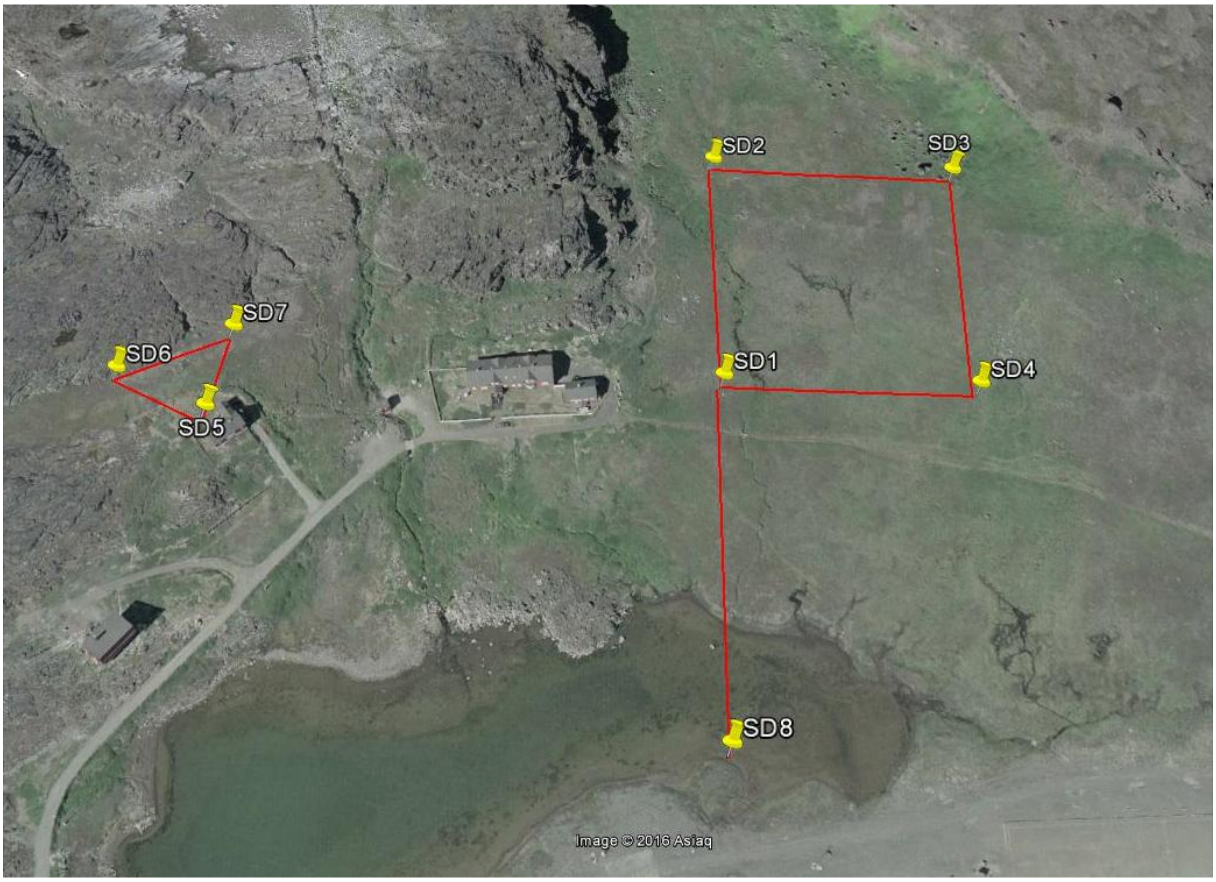


Figure 4.5. Transects/Pattern for snow depth measurements

Frequency

In November, April/May.

Equipment to be used

- Avalanche probe/steel probe
- GPS-MagnaProbe (useful for snow depth up to 1.20 m, remember to charge the battery)
- GPS-MagnaProbe operating instructions (can be found in outside pocket of the MagnaProbe backpack)
- Magnaprobe Info slides
- Folding rule, measuring tape
- Field sheet/logbook
- GPS with fix points for SD1 to SD8
- Skies with skins/Snowshoes
- Digital camera

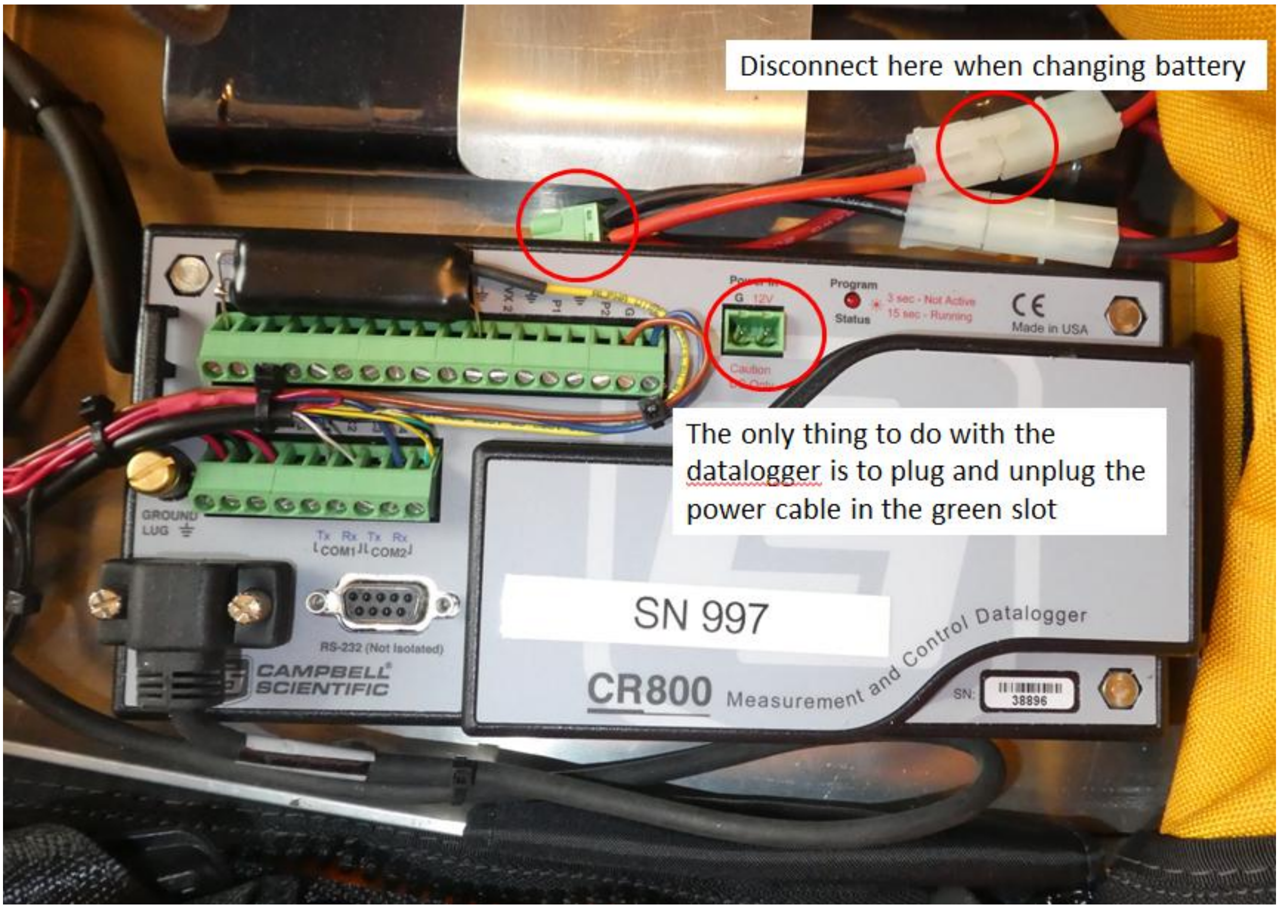


Figure 4.6 Campbell CR800 datalogger inside the backpack.

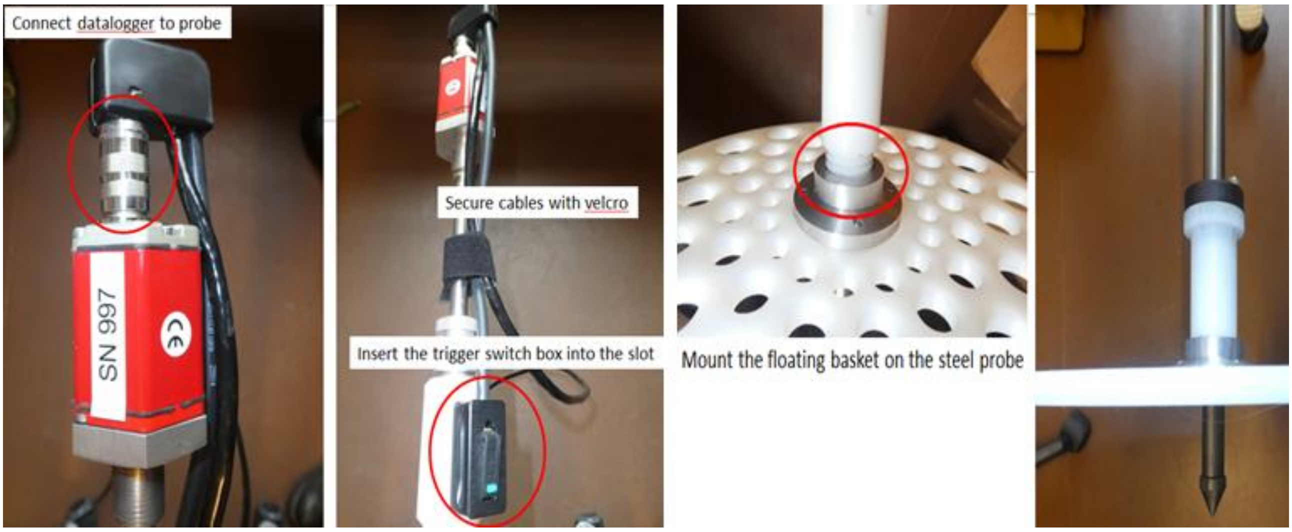


Figure 4.7 How to connect and prepare the probe.

Figure 4.8 Equipment for charging and SC115 for data dump.

Procedure

1. Test the MagnaProbe at the station, by making a calibration reading (one reading with the basket at the lowest possible position on the rod (simulating 0 cm snow depth), and one reading with the basket at the top of the rod (simulating 120 cm snow depth), following the short manual in the pocket of the MagnaProbe backpack.

2. Use map and GPS to find the starting point of the survey. Keep walking around the site to a minimum to prevent impact on the snow.

3. Record date, time and remarks about the snow surface condition (ice crust on the surface, smooth or wind-blown features on the surface, dust deposits, colour, tracks, how soft the snow is (Do you sink in with skis/snowshoes? Do you get wet boots?) in the field book.

4. Before you start, the MagnaProbe should be calibrated again by making a record with the sliding basket in the lowest position and a record with the sliding basket in the highest position on the probe. The readings should be very close to 0 cm and 120 cm, respectively.

5. Follow the instructions from the MagnaProbe Manual. Push the MagnaProbe vertically into the snow until you reach the ground. The white basket floats on the snow surface. Press the thumb switch on the handle and make a reading of the snow depth (distance from the tip of the probe to the basket). The depth and a GPS position are recorded in the data logger when the reading is made. A double beep indicates that snow depth and GPS position are recorded. Make sure to penetrate possible ice lenses/layers in the snowpack, -or make a comment if you doubt that you have reached the ground surface.

6. Use the GPS to walk in a straight line towards the next transect position and make a depth measurement for every 10 m.

7. If there is no snow, make a reading with the sliding basket in the lowest position for a 0 cm reading.

8. Snowdepths more than 1.2 m are measured by the steel probe/avalanche probe and a corresponding 0 cm reading is recorded by the Magna probe. Write the number of the reading from the data logger (channel 1) display and note the depth measured by the rod. In this way, the GPS position is recorded, and the manual depth reading can be inserted in the final datasheet.

9. Record any ice layers in the snowpack or basal ice on the ground. Record distance from the surface of the snow to the ice layer/lens. Write remarks if you doubt that you have reached the ground surface and all other comments that can be helpful when validating the data.

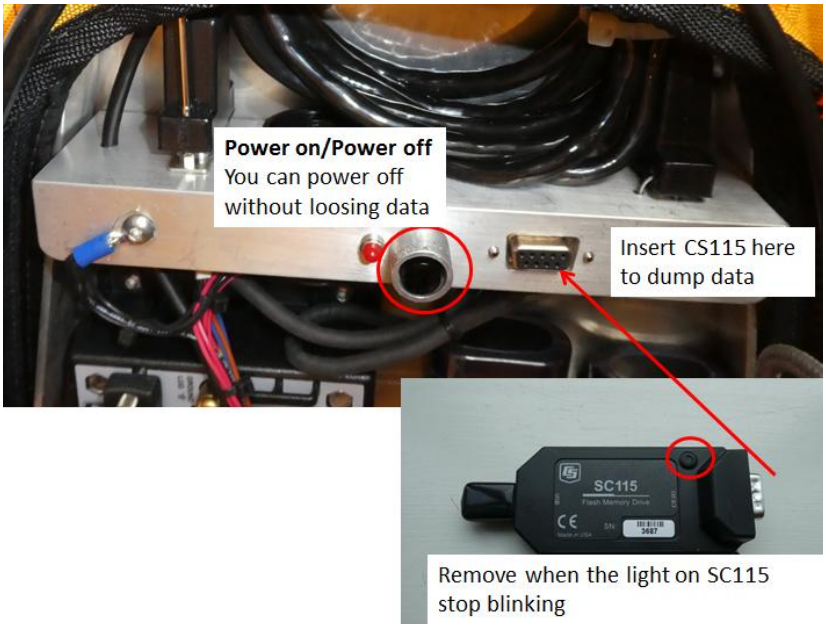


Figure 4.9 Offloading data from CR800 Magnaprobe datalogger.

4.4.3 Offload data from CR800 datalogger

Use the Memory stick (Campbell Scientific SC115, supplied with the probe) to offload data.

- Plug the SC 115 into the 9-pin plug next to the on (off push button switch. Wait for the red light to stop blinking. Remove the SC115 and plug it into a computer like a memory stick

Input of data to the local database

Data from the MagnaProbe CR800 data logger must be offloaded according to the instructions for "dumping and processing data" in the MagnaProbe manual. Data from the MagnaProbe are saved in the GeoBasis directory GeoBasis/Snow monitoring/snowdepth/Magnaprobe/Original files/yyyy-mm-dd).

Quick validation of data

- Copy the data to an excel worksheet (use template from last year).

38896	CR800	38896	CR800.Std	CPU:SN9	49142	OperatorView					
RECORD	Counter	DepthCm	BattVolts	latitude_a	latitude_b	Longitude_	Longitude_	fix_quality	nmbr_sate	HDOP	altitudeB
RN				degrees	minutes	degrees	minutes	unitless			
	Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp	Smp
168	100001	-0.038	12.46	55	41.3078	12	34.7513	1	7	1.1	12.2
169	100002	-0.038	12.42	55	41.3065	12	34.7516	2	8	1	7.7
170	100003	119.9	12.42	55	41.3061	12	34.7516	2	8	1	8

- Plot the GPS positions and check that the positions look reasonable.
- Insert all manual depth measurements (> 1.2 m) in the datasheet.
- Insert a column with remarks and include comments from your notebook.
- Mark rows with test measurements and delete any recordings that should not be included in the final sheet (incorrect recordings, double measurements etc.).

4.5 Snow density and snow water equivalent (SWE)

Snow density and snow water equivalent (SWE) at the end of winter is an important input to the water balance of the area. SWE is measured both in snow pits where densities are determined for different layers in the snowpack (section 3.4.1), and as bulk densities where snow density is measured by snow coring from the top of the snowpack (section 3.4.2)

4.5.1 Snow density in snow pits

Location

SWE are measured near the automatic weather station AWS-2 Østerlien (at least 10 m away from the mast) in order not to disturb the measuring site.

Frequency

Once a month throughout the winter –and most important before melting takes place for an end of winter SWE.

Equipment to be used

- Manual and field chart from Stine Højlund Petersen
- Snow shovel
- Thermometer
- Folding rule
- RIP cutter or snow tube
- Weight/balance/scale
- Plastic bags

Procedure

Fill out the field chart shown in table 1:

- Location
- Site
- Pit (# count snow pits through the season)
- UTM northing and easting coordinates

- Zone (UTM)
- Elevation (m. a. s. l.)
- Weather
- Ground conditions (Is the soil frozen? Bare soil or vegetation cover? Does vegetation penetrate into bottom of snowpack

<table>
<tr><td>Location:
Zackenberg</td><td colspan="2">UTM N: *XXXXXX*</td><td colspan="2" rowspan="2">Surveyors: *MRP*</td><td>Weather: *Cloudy, light wind and light snow fall.*</td></tr>
<tr><td>Site:
SPA</td><td colspan="2">UTM E: *XXXXXX*</td><td rowspan="2">Ground Condition:
Frozen ground, dwarf scrub 10 cm into bottom of snow pack.</td></tr>
<tr><td>Pit:
1</td><td>Zone:
27X</td><td>Elev: *39*</td><td>Date:
11.10.2013</td><td>Time:
12:00</td></tr>
</table>

Table 1: Example from snow pit field chart

1. Dig a snow pit. Choose a profile wall where sampling is made –it should be the wall in shadow. Clean the profile wall with a shovel.

2. Move the spatula through the snowpack (from the top of snow to the ground surface) to identify different layers in the snow, and get a feeling for variations in the density (ice lenses, loose snow, hard packed snow e.g.)

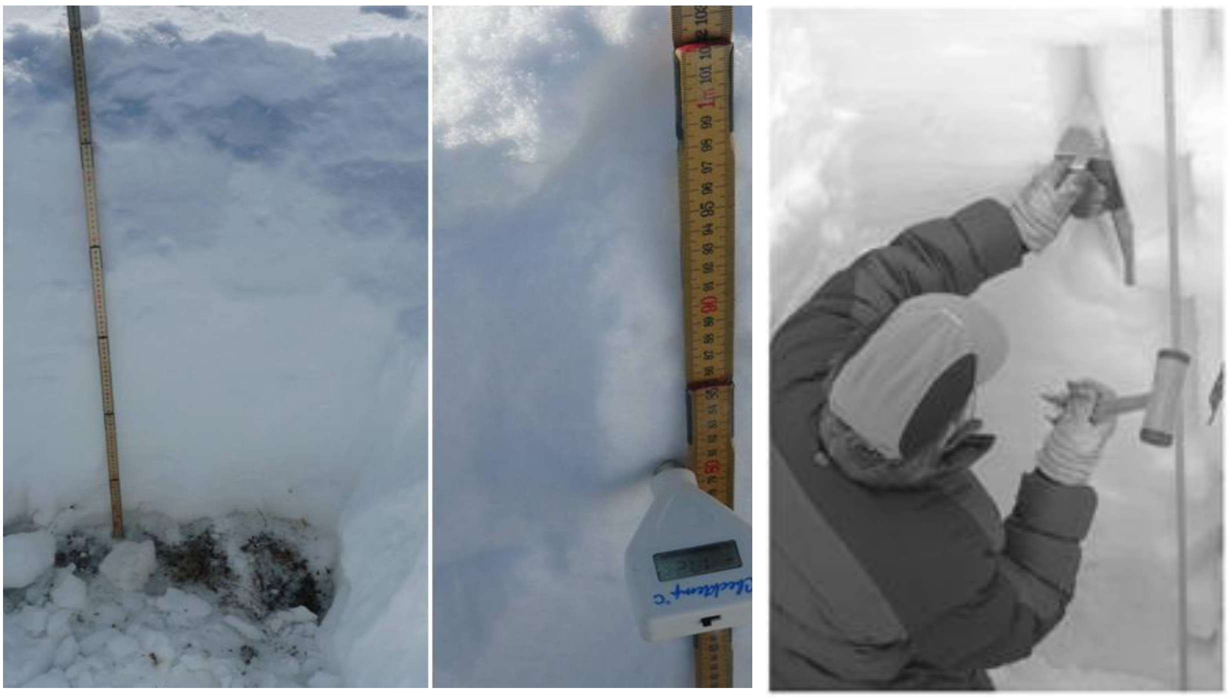


Figure 4.10 Snow pit without basal ice (left). Temperature recording (middle). Sampling of snow with a Rip cutter (right)

3. Note the depth interval of the different layers and characteristics of each different layer in the field chart. Use the codes for different crystal types (Table 3 and photo 1-6)

4. Examine the hardness of the snow and note what object can be pressed through the layer and moderate force: a fist (very loose snow), 4 straight fingers, 1 straight finger, pencil, spatula (very hard snow) or ice. If for example a pencil can be pressed into the snow but not a straight finger – you should note “Pencil” in the field chart

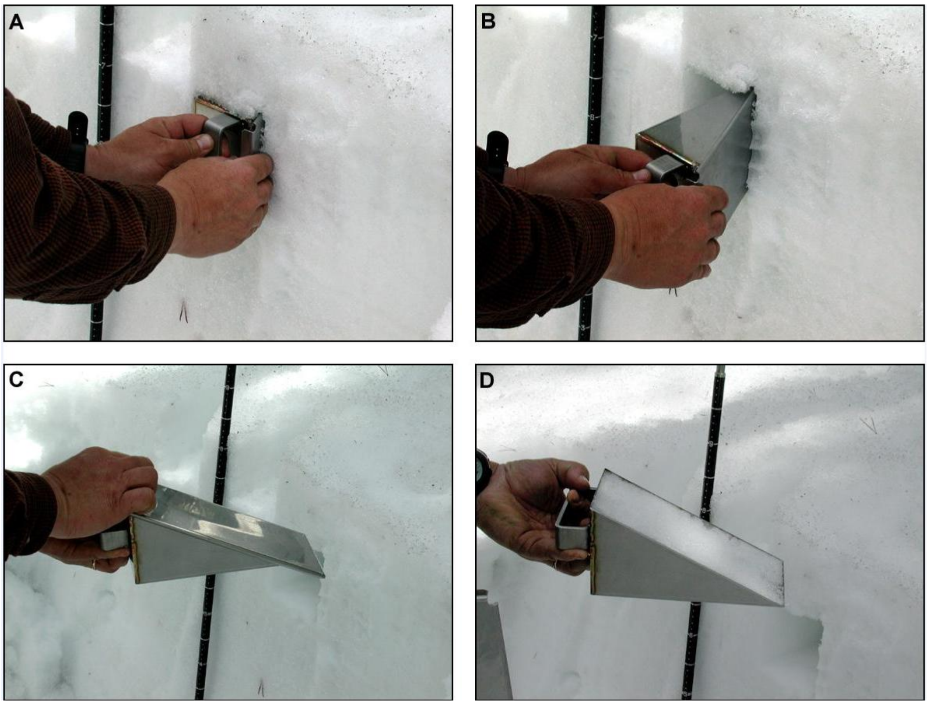


Figure 4.11 Sampling snow with a RIP- cutter

5. Place the scale on the case or on a flat board

6. Measure the weight of the sample equipment and press TARE

7. Collect a sample of snow with the RIP cutter from the layer you want or from the total snowpack (bulk density)

8. Move/brush away snow at the outside of the tube before tube and snow is placed on the scale

9. Note the weight of the snow for the given depth interval ex 72-62 cm. It is a good idea to make two parallel profiles (A and B) to calculate an average density for each layer

10. Read the temperature. Note the temperature for the given height above ground surface

11. Move the thermometer 10 cm further down

12. Repeat density measurements and temperature measurements as far down as possible –or until vegetation is reached

13. Remember to remove the thermometer, spatula, ruler and tube before refilling the pit

Table 2: Field chart with example written in italic.

Total depth (cm): *72*					**Temperature**	
Ht above ground			Density profile A	Density profile B	Ht above ground	Temp
top (cm)		btm (cm)	kg/m^3	kg/m^3	(cm)	ºC
72	-	*62*	*128*	*130*	*72*	*-4*
62	-	*52*	*214*	*215*	*60*	*-3*
52	-	*42*	*261*	*262*	*50*	*-3*
42	-	*32*	*289*	*268*	*40*	*-3*
32	-	*22*	*337*	*315*	*30*	*-2*
22	-	*12*	*351*	*368*	*20*	*-2*
12	-	*2*	*390*	*406*	*10*	*-1*
	-				*0*	*0*

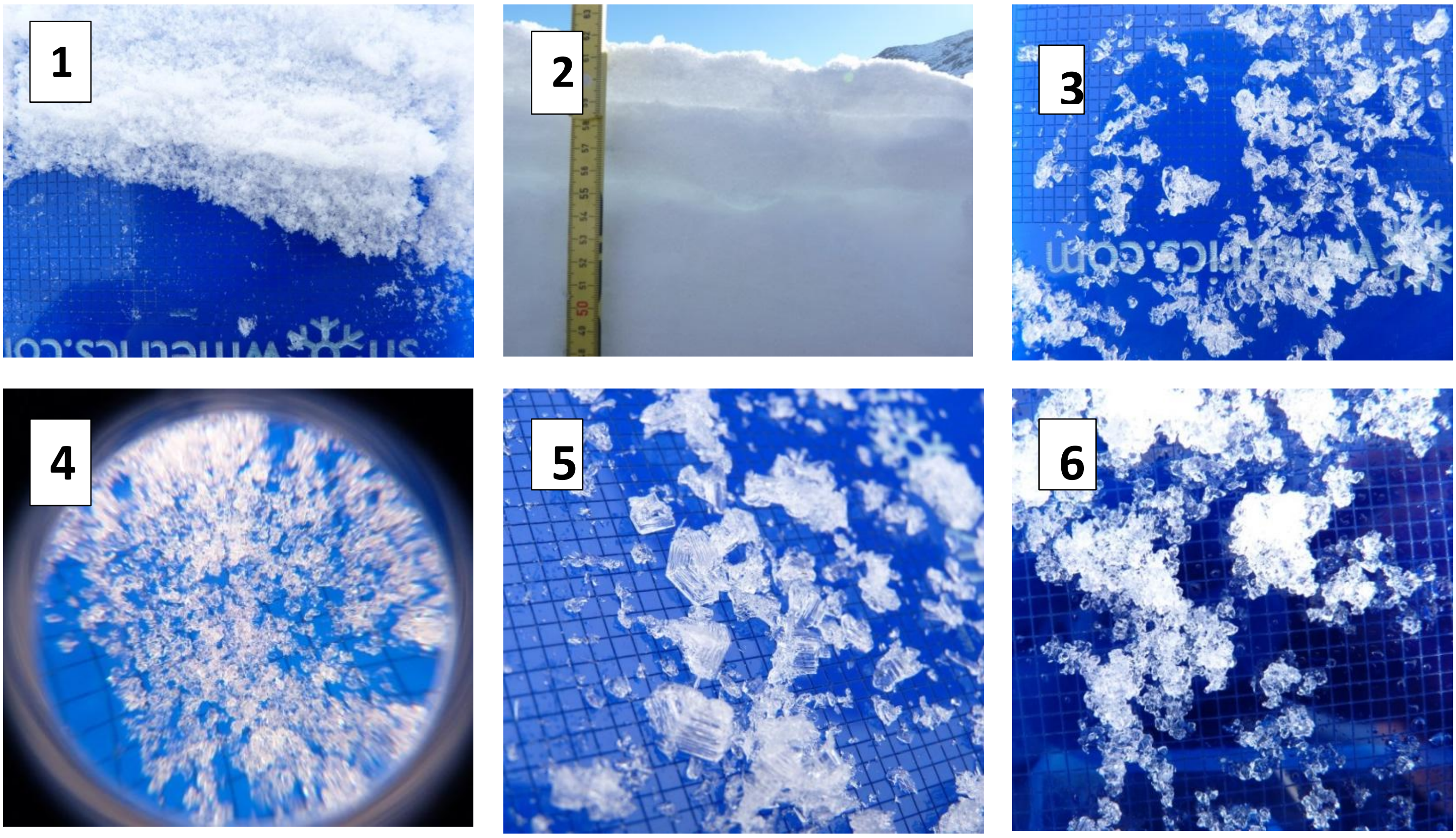


Figure 4.12: Types of crystals -see photos and see below for a description of the crystal types in the photos. Find more info about these crystal types in the snow classification in Fierz et al. 2009.

	Kode	Beskrivelse	Foto nr.
Precipitation Particles	PP	Nylig faldet sne, ses ofte på overfladen, ingen smeltning el. afrunding.	**1**
Ice Formations	IF	Islag i snepakke eller i overfladen	**2**
Faceted Crystals	FC	Krystaller m. skarpe kanter og facetter	**3**
Rounded Grains	RG	Afrundede krystaller, ses ofte inde i snepakken	**4**
Depth Hoar	DH	Løs 'sukkersne', > 10mm store krystaller, ses ofte i bunden af snepakken	**5**
Melt Forms	MF	Afrundede krystaller, der er smeltet sammen, små broer ses mellem krystallerne	**6**

Input to the local database

Snow depth and snow density data are saved in the GeoBasis directory: GeoBasis/Snow monitoring/Snow depth (or Snow density)

Date	Time	Location	Latitude	Longitude	Snow depth_cm	Sample depth_cm	Length of snowcore	Density_kg m-3	Snow classification	Snow hardness	Field staff	Method
23/03/2016	11:00	Oesterlien	69.253556	53.514722	93	63-53 cm		355	RG	Spatula	Casper Tai Christiansen	Depth specific sampling from snow pit
23/03/2016	11:00	Oesterlien	69.253556	53.514722	93	63-53 cm		395	RG	Spatula	Casper Tai Christiansen	Depth specific sampling from snow pit
23/03/2016	11:00	Oesterlien	69.253556	53.514722	93	53-43 cm		421	RG	Spatula	Casper Tai Christiansen	Depth specific sampling from snow pit
23/03/2016	11:00	Oesterlien	69.253556	53.514722	93	43-33 cm		387	RG	Spatula	Casper Tai Christiansen	Depth specific sampling from snow pit

4.5.2 Snow bulk density (snow sampling tube)

Follow instructions from the Snow Survey Sampling Guide (a short version is given here in this manual) and fill out the field chart.

Frequency

Once a month throughout the winter –and most important before melting takes place for an end of winter SWE.

Location

Bulk density measurements are made in Østerlien. Samples should be taken at least 10 m away from the automatic stations in Østerlien in order to minimize impact of the snow.

Equipment to be used

- Snow Survey Sampling Equipment (Snow-Hydro)
- Spanner wrenches
- Thread protector
- Driving wrench
- Weighing scale and cradle
- Snow survey sampling guide
- Field chart 2, App 2
- Handheld GPS
- Ranging pole

Figure 4.12 Snow Survey Sampling Equipment (Snow Hydro)

1. Go to the site. Find an undisturbed snow surface. Record the position from the GPS

2. Measure snow depth with a steel probe/avalanche probe

3. Check the tube for cleanliness (no snow inside the tube). Weigh the empty tube.

4. Hold the sampling tube vertically and drive it to the ground surface. Be sure the cutter penetrates to the ground surface. Before rising the tube, read the depth of snow on the outer side of the tube.

5. Turn tube at least one turn to cut the core loose. Carefully raise tube, look through slots and check that the snow core is intact, read lengths of snow core (core length should be at least 90 percent of the snow depth except in snow of very low density or mushy snow. If not, resample.

6. Use a folding rule to measure the exact depth of snow where the sample was collected. Insert the folding rule in the hole and read cm at the snow surface (Figure 3.9).

Figure 4.13 Snow sampling tube. Scale and plastic bag with snow core.

7. Inspect cutter end of tube for dirt or litter. Use a knife/multi-tool to carefully remove soil and litter from the cutter and tube. Correct the reading for snow depth and core length by subtracting the distance driven into soil or litter

8. Carefully balance the sampling tube containing the core on the weighing cradle or on a scale. If windy, point the tube into the wind. Record the weight in the field chart. Or the snow can be transferred from the tube to a pre-weighed plastic bag and measured more accurately. If it is windy or too cold for the scale to work outside, consider bringing samples into the station in labeled plastic bags and weighing inside.

9. Remove the snow core from the tube and start over again.

10. For each site sample at least 3 cores.

5 Soil /ground monitoring

5.1 Introduction

The GeoBasis program measures different parameters in the topsoil/ground. In large areas of the Arctic only a shallow soil layer covers a permanent frozen layer of soil/ground or bedrock. The permafrost has a huge impact on drainage patterns in these areas as the permafrost table acts like a non-permeable layer and thawing of the permafrost has the potential of releasing greenhouse gases when soils thaws and stored carbon can be turned over. The area around Arctic Station Disko is an area with discontinuous to sporadic permafrost.

Parameters measured

- Soil thaw and active layer
- Soil moisture
- Soil temperature
- Soil water chemistry

GeoBasis monitors soil thaw and active layer depth. The active layer is the part of the soil that is object to seasonally thawing and freezing. Within the active layer/topsoil, we measure soil moisture and soil temperature year-round -both parameters are of vital importance for most soil processes. Soil moisture and soil temperature, for example, strongly affect the microbial activity in soils, which controls nutrient release and carbon release into the soil water and to the air. Finally, we monitor soil water/solution chemistry over the growing season. Soil water chemistry is likely to be affected by physical and chemical changes in the environment and to have important effects on ecosystem processes and plant productivity.

Where to find data in the GEM Database

Program/ Program group/Group-element:

GeoBasis Disko / Soil / AWS2-GroundSurfaceTemperature
GeoBasis Disko / Soil / AWS2-GroundTemperatureProfile1
GeoBasis Disko / Soil / AWS2-GroundTemperatureProfile2
GeoBasis Disko / Soil / AWS2-SoilHeatFlux
GeoBasis Disko / Soil / AWS2-SoilMoisture
GeoBasis Disko / Soil / AWS2-SoilTemperature
GeoBasis Disko / Soil / AWS3-SoilMoisture
GeoBasis Disko / Soil / AWS3-SoilTemperature
GeoBasis Disko / Soil / AWS4-SoilMoisture
GeoBasis Disko / Soil / AWS4-SoilTemperature
GeoBasis Disko / Soil / Soil water chemistry

5.2 Soil thaw and active layer development

A Circumpolar Active Layer Monitoring (CALM)-site was established in Blæsedalen in 1997 by Hanne Hvidtfeldt Christiansen. More info about this CALM network can be found here https://ipa.arcticportal.org/activities/gtn-p/calm/16-calm

Rocks and boulders in the soil have made measurements at this site almost impossible –and the uncertainty of the depth measured was too high. Therefore, this site is no longer part of monitoring. To follow the permafrost table other methods must be considered e.g. boreholes and ground temperature monitoring.

However, we have decided to carry on regular measurements from the four corners of the grid in a period to evaluate what we can do here. And once a year we will measure active layer depth in the entire rim of the site.

Location

The CALM site at Disko Island (DISKOCALM-1) is located on top of Pjeturssons moraine ridge in Blæsedalen. The site consists of 100 measuring points in a 90 x 90 m grid. There are 10 m between every node. Nodes are marked with white painted stones (corner stones are yellow/red or marked with poles)

ID	Location	UTM	Northing	Easting	Elevation	Decimal degrees	
NV-hjørne	CALM plot Pjetursson	22W			123	69.27313	53.48222
NØ-hjørne	CALM plot Pjetursson	22W			115	69.27343	53.47998
SØ	CALM plot Pjetursson	22W			117	69.27262	53.47906
SV	CALM plot Pjetursson	22W			108	69.27236	53.48127

Figure 5.1 CALM site at Pjeturssons moraine ridge, Blæsedalen.

Procedure for active layer measurements

1. Start in one of the corners in the grid net. Make sure that the orientation of the field chart is right compared to the grid.

2. Press the steel rod vertically down in the ground. When the tip of the rod touches the frozen surface, a finger is placed on the rod at the soil/litter surface. Pull up the rod and read the depth on the centimetre division. <u>There are several stones/boulders in the soil which makes it difficult to reach the permafrost –or hard to decide if it is the frozen surface or s stone. Pay attention and try again nearby if in doubt</u>

3. Note the depth in the field chart. It is important, that all measurements are made to the soil surface and not the vegetation surface

4. Take photos from the site and a 360° panorama

Input of data to local database

Write values from the field chart into a worksheet. Grid nodes are numbered 1-100 beginning in the NW corner and reading down the rows as you would read a text. Thus, the last grid node 100 is in the southeast corner. Name the file “DiskoCALM_YYYY” and save the data in the folder: GeoBasis/Active layer/CALM/

NW NE

10	1	2	3	4	5	6	7	8	9	10
9	11	12	13	14	15	16	17	18	19	20
8	21	22	23	24	25	26	27	28	29	30
7	31	32	33	34	35	36	37	38	39	40
6	41	42	43	44	45	46	47	48	49	50
5	51	52	53	54	55	56	57	58	59	60
4	61	62	63	64	65	66	67	68	69	70
3	71	72	73	74	75	76	77	78	79	80
2	81	82	83	84	85	86	87	88	89	90
1	91	92	93	94	95	96	97	98	99	100
Y/X	1	2	3	4	5	6	7	8	9	10

SW SE

Figure 5.2 Field chart with numbering of grid nodes.

Figure 5.3. Probing the soil. A steel probe is forced vertically into the soil to reach the frozen surface.

5.3 Soil temperature

Soil/ground temperatures are automatically measured year-round at the automatic weather stations AWS1, AWS2, AWS3 and AWS4 (for details about depth see appendix 1). The longest time series from Arctic Station reach back to 1991 where ground temperatures in 5, 60, 175 and 300 cm depth were monitored (Figure 5.4). At this site the soil was permanently frozen at the depth of 175 cm in the early 1990tis, but significant warming resulted in a thawing at this depth.

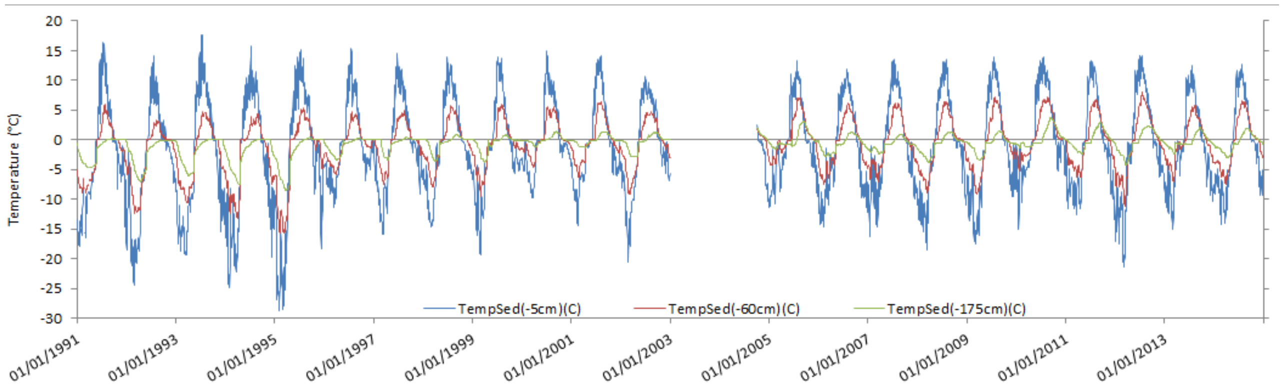


Figure 5.4 Ground temperatures measured at AWS1 at the scientific leader's house (5 cm, 60 cm and 175 cm)

Additional ground temperature measurements are now included in the monitoring. There are 2 new profiles at AWS2 in Østerlien (P1 and P2), the deepest borehole (P2) has a thermistor at 350 cm (Figure 5.5). Data from this site shows no freezing at any time of the year within the upper 350 cm's depth. However, there are permafrost in some areas. Southern Disko is in the zone of discontinuous permafrost.

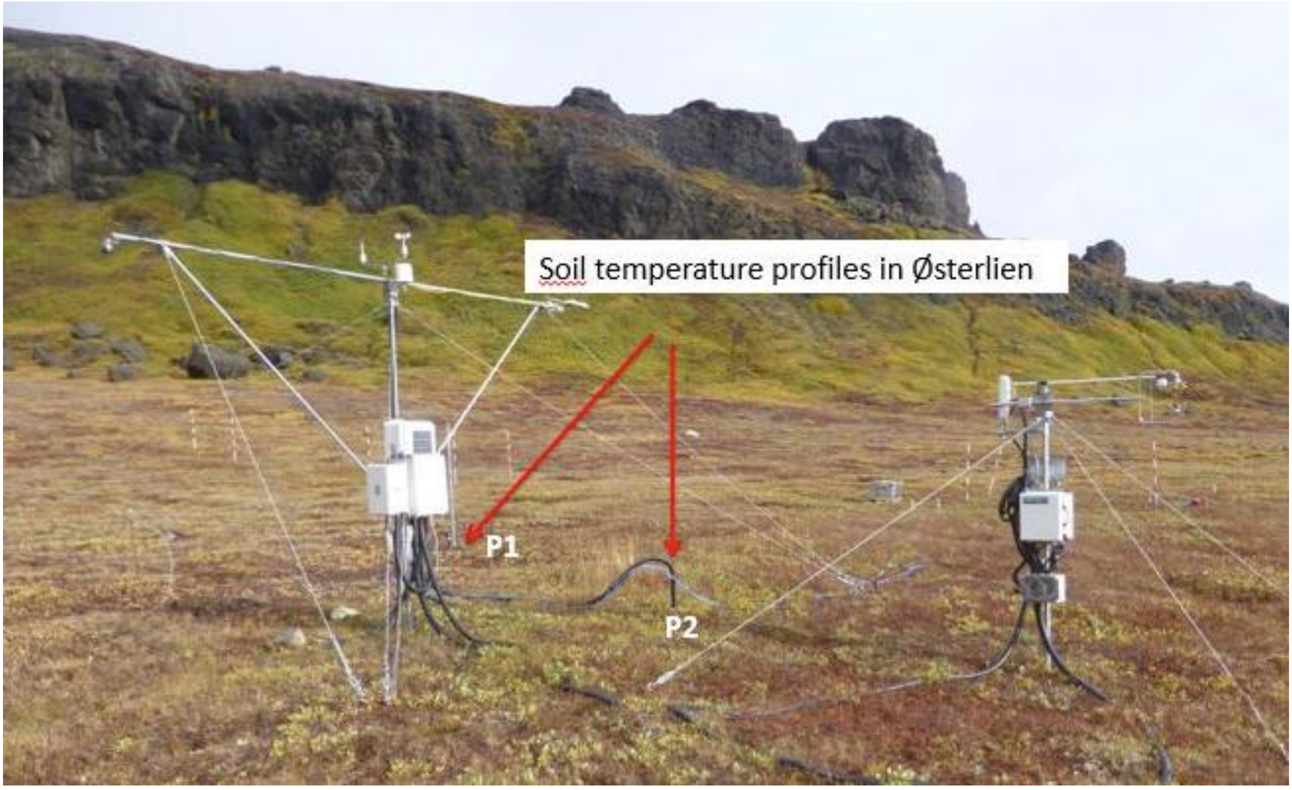


Figure 5.5 Ground temperature boreholes equipped with thermistor strings at AWS2 Østerlien. P1 is 150 cm deep and P2 is 350 cm deep. See Appendix 1 for details about installation.

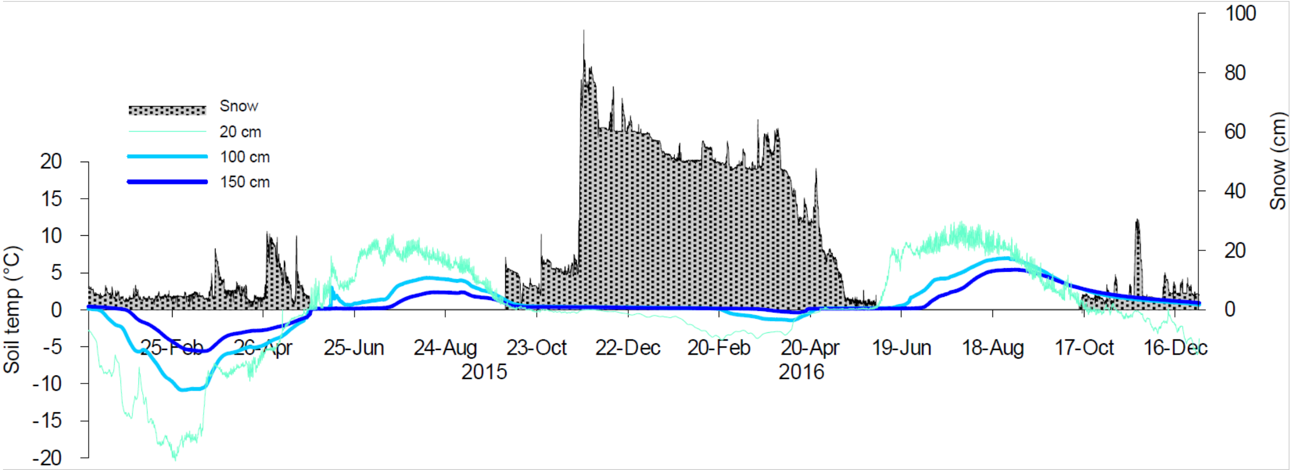


Figure 5.6. Snow depth and ground temperatures in 20, 100 and 150 cm's depth in Østerlien shown for 2015 and 2016 illustrates the insulating effect of the snow. The soil/ground reached lower temperatures and was frozen for a longer period when the snow depth was low.

Besides the soil profiles, soil surface temperature is measured along the transect (T1-T4) from sea level to top of Skarvefjeld (section 2.5).

Automatically logged soil parameters are found within the datasheet from each of the weather stations. Follow the procedure given in section 2.2.1 for offloading data at AWS2 Østerlien, section 2.3.1 for offloading data at AWS3 Blæsedalen and 2.4.1 for offloading data from AWS4 Skarvefjeld.

In the summer of 2018, a soil temperature profile was made at Pjeturssons moraine next to the mast T1 (Figure 2.1 and 5.6.1) adjacent to the CALM site (see 5.3.1).

5.3.1 T1-ground

T1-ground next to T1

T1 ground is located on the top of Pjeturssons moraine ridge. It is a flat open vegetation covered area.
Position (decimal degrees): 69.27300, -53.47940
Elevation: 125 masl
Operation: 2018-
Instrumentation: sensors in 30 cm, 70 cm and 85 cm's depth
Power: Battery ½AA
Datalogger and download: Tinytag dataloggers
Time stamp raw data: UTC-2
Logging interval: every hour

Include Tinytag at AWS2 and AWS3

Figure 5.6.1 Tinytag dataloggers inside the grey box at T1-ground. Installation depths 30, 70, 85 cm

5.3.2 Offload data from Tinytag dataloggers

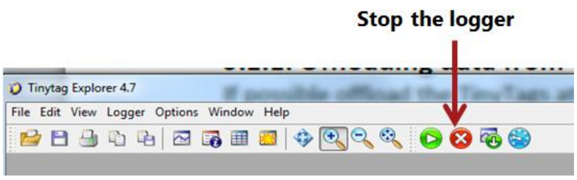
Equipment

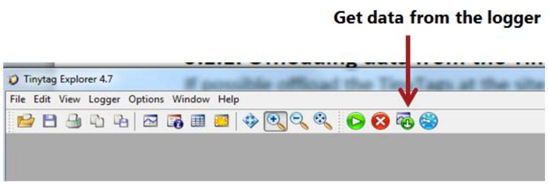
- Tinytag software: Tinytag Explorer 4.7 (In the Software folder for GeoBasis)
- Screw driver (flat head)
- Batteries (3.6 V, half size AA batteries, lithium - new batteries are wrapped in plasticbags –one single battery in each bag)
- Tinytag communication cable
- Bag with extra screws and nuts, O-rings and 2 g silica bags

Procedure

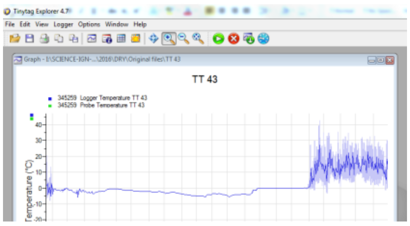
- Open Tinytag Explorer on the labtop (Tinytag Explorer 4.7)
- Remove the metal cap from the plug on the sensor and connect the cable (on the side of the logger with the red and green led)

- Press [stop the logger]- If you only need to offload data and not clear the memory you can skip to stop the logger and proceed directly to next step. <u>If you stop the logger: Remember to launch the logger after offloading data.</u>





- Press [get data from the logger]
- Save the file with the name of the logger [File] [Save as]. The file will have the extension .ttd.



- From Tinytag Explorer you can export data to a spreadsheet. Press [Open the table of readings view], press on the File drop down list and choose 'Export All Cells'

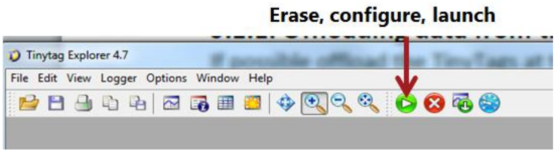
Change battery in Tinytag dataloggers

The battery is changed every second year –see Fieldwork plan for info about this

- Undo the 4 screws and open the logger (carefull not to loose the 4 nuts)
- Remove foam pad and silica bag
- Remove old battery
- Insert new battery –make sure it is placed correct
- Place foam and silica bag and close the logger –tighten the lid

Restart and launch Tinytag datalogger

- Please make sure that the time of the computer is set to UTC-2
- Connect communication cable to tinytag and computer
- Press the [**erase, configure, launch**]-icon to communicate with datalogger



- *Configuration settings:*
  1. *logging every 1 hour*
  2. *(stop when full)*
  3. *delayed start: nearest coming hour HH:00.*

- Press [start the logger]
- Take a screenshot/photo of the configuration box shown on the screen
- When the logger is started you will see a short flash of light in the green led in a regular interval (old loggers have 2 short flashes until time of start -if delayed start is chosen.

5.4 Soil moisture

Soil moisture is a key parameter and essential for a lot of processes in the soil. As part of GeoBasis, soil moisture is automatically measured year-round at the automatic weather stations AWS2, AWS3 and AWS4 (for details about installation, see appendix 1). During snowmelt most soils are saturated for a shorter or longer period. Peaks later in the season are caused by rain events. The freeze in period is highly affected by the moisture content in the fall and by the timing and the amount of snow on the ground. If the soil is very wet and a thick layer of snow covers the soil in the early winter the freeze-in period is prolonged.

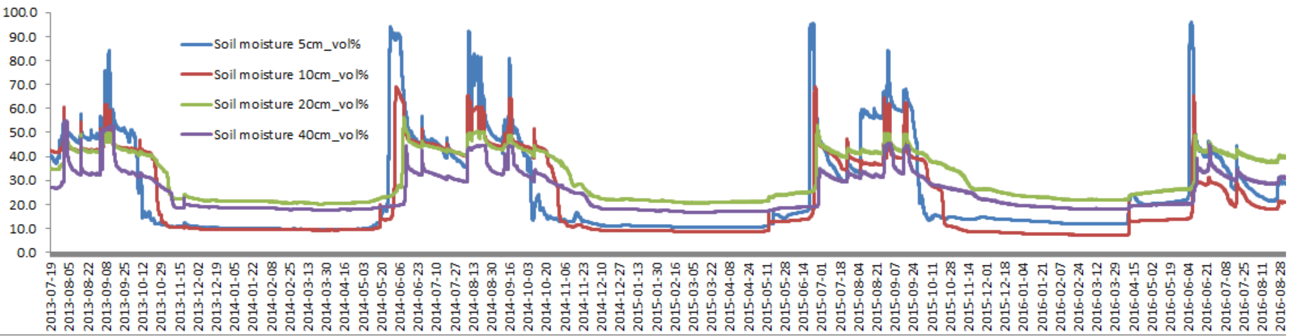


Figure 5.7 Soil moisture monitoring from AWS3 in Blæsedalen.

5.4.1. Offload data

Automatically logged soil parameters are found within the datasheet from each of the weather stations. Follow the procedure given in section 2.2.1 for offloading data at AWS2 Østerlien, section 2.3.1 for offloading data at AWS3 Blæsedalen and 2.4.1 for offloading data from AWS4 Skarvefjeld.

5.4.2 Manually measurements of soil moisture

Manually measurements of soil moisture in Østerlien are carried out every week around the site where soil water is being collected (see section 5.5). Soil moisture is measured from the soil surface and gives the soil moisture average within the topsoil 0-6 cm. Measurements are carried out as 5 random readings around the soil water site (see section 5.5).

Theta probe MLx2 and HH2-meter

Include section about TOMST sensors

5.5 Soil water chemistry

Soil water is collected at the site SW1 in Østerlien using soil water samplers (suction cup lysimeters) from Prenart. The suction sampler used at Arctic Station is 'Prenart Super Quartz' made of porous PTFE (teflon) and quartz. They can be applied for soil water sampling in all soil types and are most applicable for investigations of soil nutrient status. Prenart super quartz soil water samplers consist of a 95 mm long cylindrical ceramic probe (21 mm in diameter) (pore size: 2 microns). In one end, a 5 m long Teflon tube (5 mm outer diameter) links the probe to a 2 L plastic bottle.

Location of SW1

Located 150 m west of the garage at Arctic Station in a gentle south sloping area covered by low vegetation/dwarf shrubs (Figure 5.8).
Position (decimal degrees): 69.25349°, -53.51363°
Elevation: 25 m a.s.l.
Operation: 2012-
Installation depth: 10, 20, 30, 40, 50 cm

Figure 5.8 Soil water sampling at SW1 site in Østerlien

Frequency

From the soil thaws in May/June until the soil freezes in September/October soil water is collected from the top 50 cm of the soil on a regular basis. Lysimeters are buried at 10, 20, 30, 40 and 50 cm in Østerlien near AWS-2. Water is collected approximately every second week (see field plan) and various analysis are carried out on the samples (see below).

Parameters to be measured

- BIO Dissolved Organic Carbon (DOC)
- AS Conductivity/ Specific conductivity
- AS Alkalinity
- IGN Chloride (Cl^-)
- IGN/BIO Nitrate (NO_3^-)
- IGN Sulfate (SO_4^{2-})
- IGN Calcium (Ca^{2+})
- ÏGN Magnesium (Mg^{2+})
- IGN Pottasium (K^+)
- IGN Sodium (Na^+)
- IGN Iron (Fe^{2+})
- IGN Aluminium (Al^{3+})
- IGN Manganese (Mn^{2+})
- BIO Ammonia (NH_4^+-N)
- BIO Dissolved total nitrogen (DTN)
- BIO Total Phosphorous (PO_4^{3+}-P)

The prefix tells where the analysis is carried out. ***AS****=Arctic Station,* ***IGN****=Department of Geosciences and Natural Resource Management, University of Copenhagen,* ***BIO****=Department of Biology (Terrestrial Ecology) University of Copenhagen*

5.5.1 Sampling of soil water

Equipment to be used for applying vacuum

- Prenart collecting bottles with screw caps (2000 ml) (located at the site)
- Battery vacuum pump
- Field chart 'Soil water'/ Notebook
- Pinch clamps (spare)
- Silicone rubber tube (spare)
- Handheld soil moisture meter (theta probe)
- Metal probe/steel probe to measure thaw depth (only in June)

Figure 5.9 Soil water bottles hidden in grey storage tubes with red lids. Lysimeters buried in 10-50 centimeters depth.

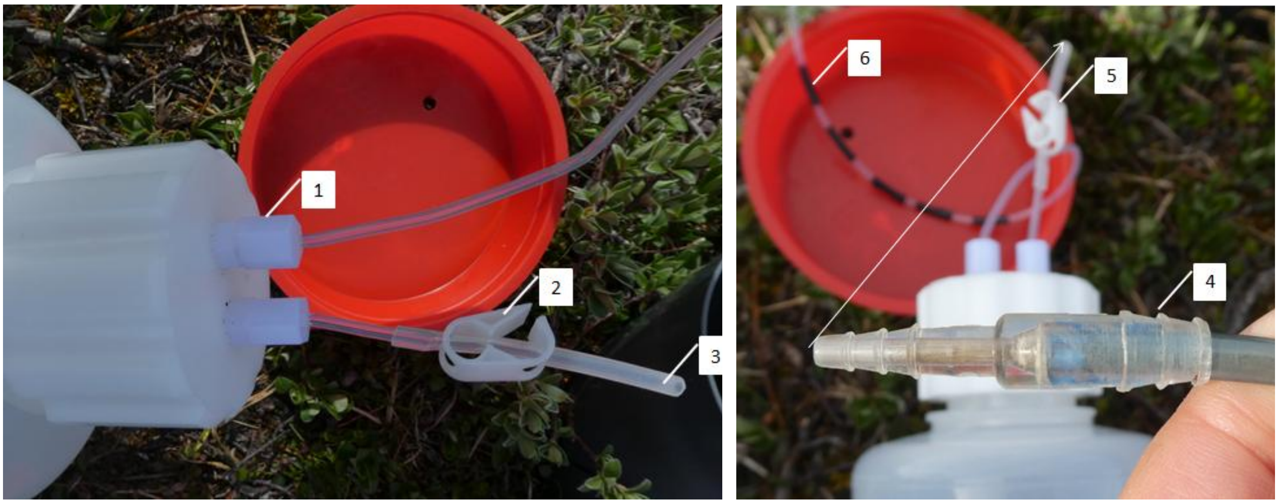


Figure 5.10. Teflon tube from the lysimeter enters the bottle through the valve (1). Pinch clamp (2+5) on the soft silicone rubber tube (3). Connect the soft silicone tube (3) to the connector from the pump tube (4) (remember to open the pinch clamp (2) when using the pump and close it before disconnecting the tube from the pump). Tape on the tube (6) mark depth of installation (every tape mark is 10 cm).

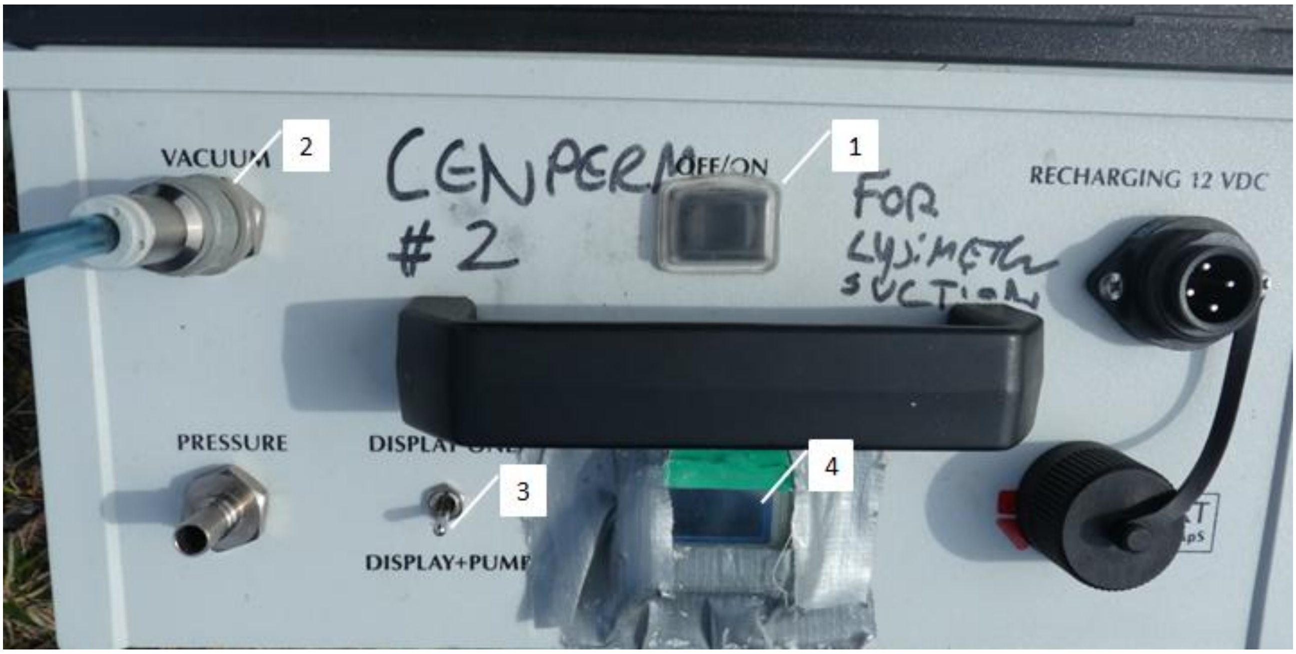


Figure 5.11. Display on the vacuum pump. Switch ON/OFF (1). Attach the tube to the vacuum hose (2). Switch to Display and Pump (3). Display showing millibar (4).

Procedure for applying vacuum

1. Apply vacuum on the bottles 2-3 days before you expect to collect the water.

2. Open the buried grey cylinder with red lid (Figure 5.9). Inside there is a 2 L plastic bottle connected by Teflon tube to the lysimeter installed in the soil.

3. Open the pinch clamp and ensure that the tubing walls are separated (Figure 5.10). Squeeze the tube over the connector from the pump tube.

4. Apply a vacuum of 400 millibar using the electrical pump. Discard the first few ml of water entering the bottle.

5. Apply vacuum. Record day and time for application of vacuum in the field chart

6. Measure soil moisture at five random spots adjacent to the site (use theta probe ML2x). Avoid the area upstream from where the bottles are buried. Insert the Theta probe into the soil from the ground surface. Do not force the probe down. If you hit a stone, just move the sensor and try another place. Read results on the HH2-meter. Check if the HH2 meter is set for Organic or Mineral soil. In Østerlien select Mineral soil.

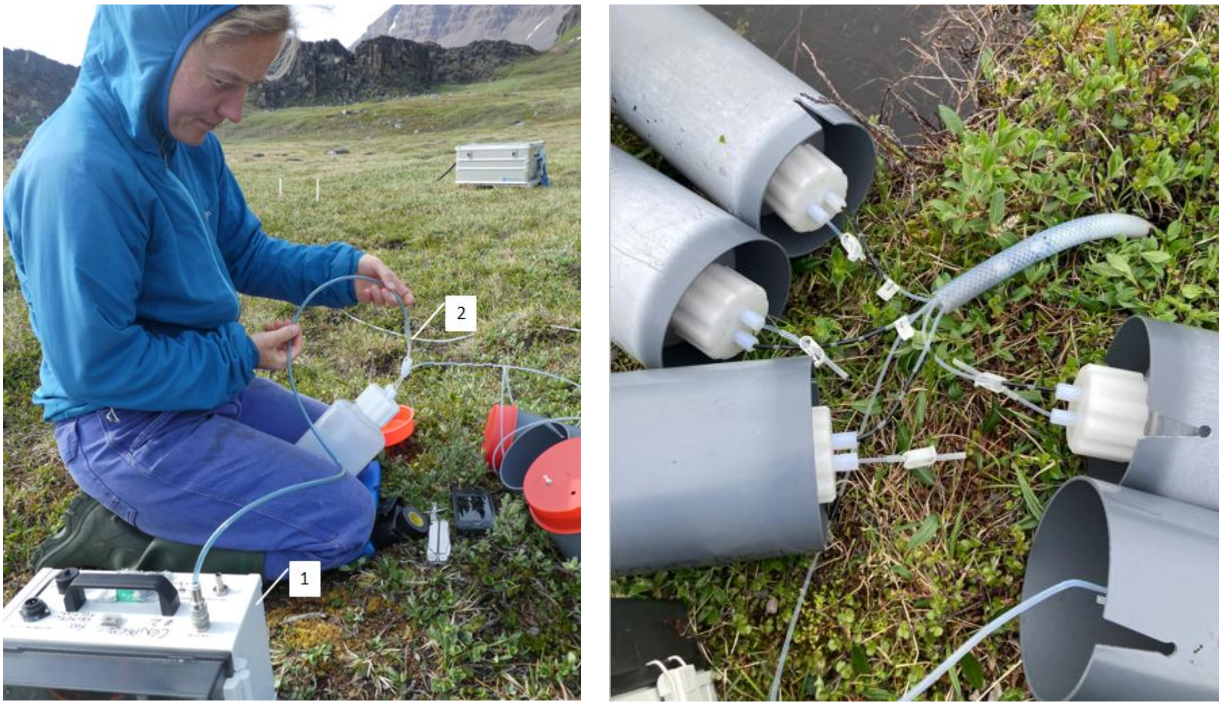


Figure 5.12. Electrical pump (1) connected to the soft silicone tube on the bottle (2)

Procedure for collection

1. Bring 15 x 50 ml vials (yellow cap). All bottles pre-marked with sample ID on the lid and on the vial:
   SW1_DDMMYYYY_XXcm-BIO
   SW1-DDMMYYYY_XXcm-IGN
   SW1-DDMMYYYY_XXcm-AS

2. Remove the red lid from the grey tube and inspect the 2-liter bottle with soil water. Record the approximate total volume of soil water from the scale at the bottle. If there is no water in the bottle, then check if there is still vacuum (listen when you open the clamp). If there's no vacuum, then tighten the lid on the bottle and the caps on the lid and inspect the Teflon tube for any leaks before applying a new vacuum.

3. Make sure you place the lid in a dry place to avoid any dirt in the bottle. Pour a few ml of soil solution into each 50 ml plastic vial. Shake the vial vigorously and discard before filling with approximately 30 ml (leave space for increasing volume of the water when freezing). If there´s less than 100 ml water, then apply a new vacuum to the bottle.

5. Record information about the soil solution (transparency, color, precipitates etc.) in the field chart.

6. If there is more soil solution in the bottle, then fill the vial for IGN and the one for AS. Discard the rest of it. Close the 2-liter bottle and press the clamp on the tube. Leave the bottle in the grey cylinder and place the red lid on top.

7. Bring the samples to the Arctic Station Lab.

5.5.2 Procedure in the Lab

1. Store the 50 ml samples for BIO in the freezer <-18°C (yellow rag). No need for further filtration of these samples as the lysimeters have a pore size of 2 microns.

2. Store the 50 ml sample for IGN in a yellow rag in the fridge. No need for further filtration of these samples as the lysimeters have a pore size of 2 microns.

3. Measure conductivity in the 50 ml soil water sample (the one for AS) according to the procedure given in section 7.1.

4. After conductivity is measured, use the sample called AS for pH and alkalinity analysis. Preferably, 50 ml but in case of limited amounts of water, samples down to 15 ml can be used. pH and alkalinity tests are made on the same sample according to the procedures given in section 7.2 and 7.3

5. Ship all the samples to Denmark at the end of the field season. Bring the IGN subsamples to the Department of Geoscience and Natural Resource Management, University of Copenhagen for further analysis. Bring the BIO subsamples to the Department of Biology (BIO) for further analysis.

Contact:
Department of Geosciences and Natural Resource Management (IGN), University of Copenhagen, Denmark
Attn: Søs Marianne Ludvigsen (Laboratory)

Contact:
Department of Biology, University of Copenhagen, Denmark
Attn: Anders Michelsen

6 River water monitoring

6.1 Introduction

Monitoring of the hydrology in the river Kuussuaq (Røde Elv) started in 2013 and is now a part of the GeoBasis programme. The name of the river refers to the reddish color of the river caused by the iron rich material from decomposition of the basaltic mountains/bed rock in the area. Runoff from Røde Elv drainage basin is an important part of the water balance and an essential tool to estimate the total output of freshwater, sediment, and nutrients from the land to the ocean. The drainage basin/watershed for Røde Elv vary in elevation from 0 to about 800 m asl and the size is estimated to 100 km^2 of which roughly 20% is glacier covered (Figure 6.1).

As part of the river monitoring a gaging station with a multi-sonde on a steel rag is submerged in the water every spring/summer. In 2015, the gaging station found its present position on a rock-wall north of the bridge at the eastern side of the river (Figure 6.4). Multiple parameters like water level, water temperature, turbidity, conductivity and pH are recorded automatically (Figure 6.2 and 6.3).

Manual discharge measurements are carried out to transform the automatically logged water level into discharge.

Besides the automatic measurements water samples are collected manually every third day and analyzed for suspended sediment, major anions, cations and nutrients.

Fig 6.1 Outline of the drainage basin for Røde Elv. Yellow dot is the site where sensors are installed

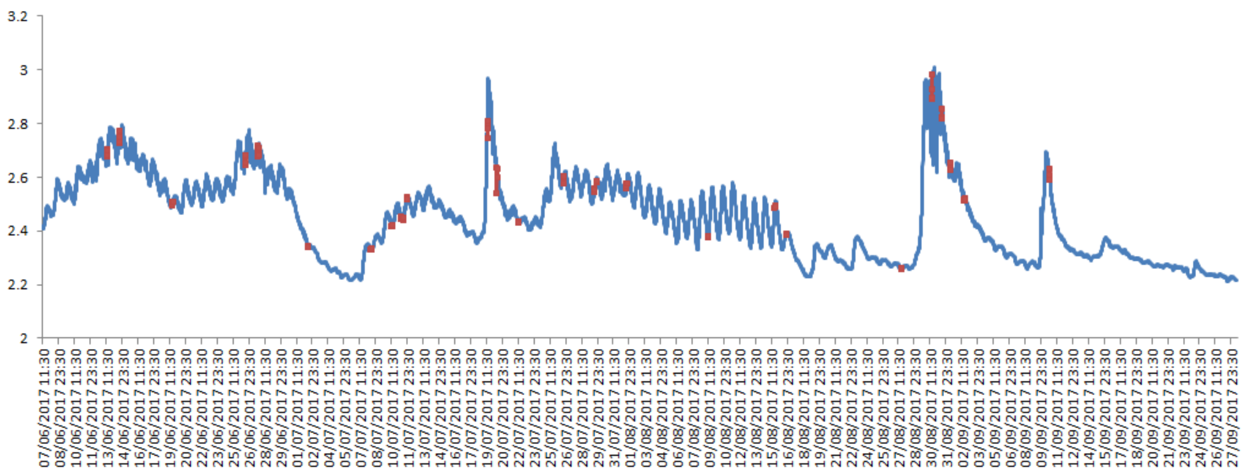


Fig 6.2 Water level variations during the main runoff season in Røde Elv (7 June to 27 September 2017). Red dots mark manually discharge measurements.

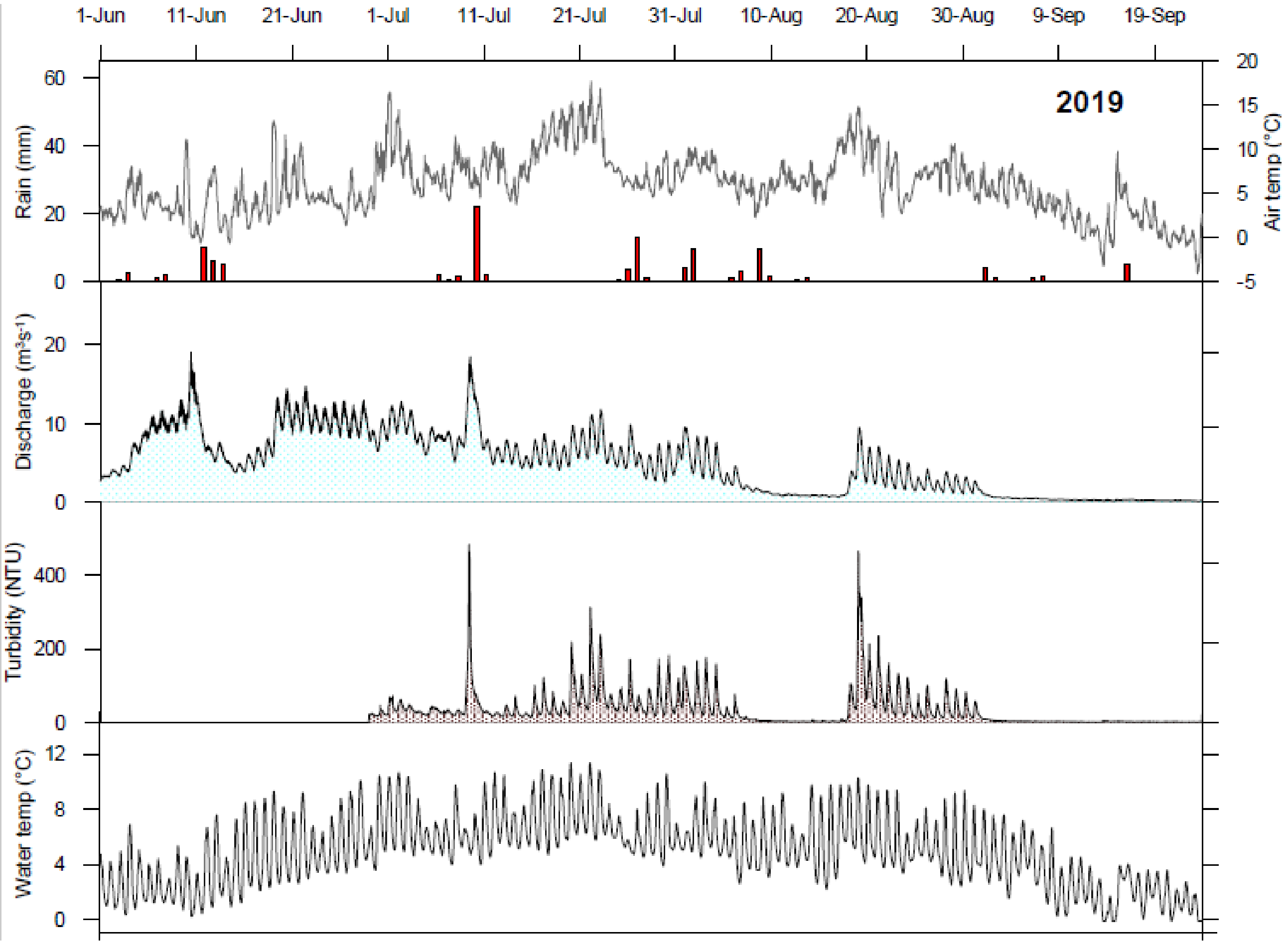


Fig 6.3 Outline of Air temperature and precipitation, water discharge, turbidity and water temperature in the runoff season 2019.

Parameters to be measured

- Water level
- Water discharge
- River water chemistry
- Suspended sediment

Where to find data in the GEM Database

Program/Program group/Group-element:

GeoBasisDisko/Hydrology/RE-1-Multisensor (from the position in 2013)
GeoBasisDisko/Hydrology/RE-2-Multisensor (from the position in 2014)
GeoBasisDisko/Hydrology/RE-Multisensor (from the position 2015-present)
GeoBasisDisko/Hydrology/RiverWaterChemistry
GeoBasisDisko/Hydrology/SuspendedSediment
GeoBasisDisko/Hydrology/WaterDischarge

6.2 Automatic water level monitoring

To estimate the total runoff from the drainage basin outlined in figure 6.1 we use continuous recordings of water level in Røde Elv (Figure 6.2) and discharge measurements. As soon as the water starts to run in the spring (after spring break-up) a multi-sonde and a water-level logger is submerged in the river Røde Elv.

The multi-sonde (YSI EXO2) measures:

- Water temperature
- Salinity
- Turbidity
- Conductivity
- pH
- Water level

For backup an extra **water level logger (HOBO U20-001-04)** is added to the setup. The HOBO logger measures:

- Water temperature
- Water level

The multi-sonde and the water-level sensor are removed from the river before ice cover the sensors (late September/early October) and replaced by a winter set-up.

Location

The present position (since 2015) of the multi-sonde is on a steep rock-wall north of the bridge at the eastern side of the river (Figure 6.4 and 6.5)
Position (decimal degrees): 69.25362°, 53.49823°
Elevation: 7 m a.s.l
Operation: 2015-
Time: (UTC-2) (in the GEM database the time is UTC-3)
Logging interval: 15 min

Figure 6.4 Present location of the multi-sonde in Røde Elv since 2015, and the position close to the bridge in 2013.

6.2.1 Calibration of Multi-sonde

The multi-sonde needs calibration before mounting. Use the software KorEXO and follow the EXO2 User manual.

6.2.2 Mounting of the multi-sonde

After the river breaks up in the spring, it is time to install the multi-sonde. Bring the calibrated multi-sonde (3 in Figure 6.5) and the steel casing (2) to the river. Mount the multisonde in the two P-clamps (4) inside the steel casing. Mount the water level logger (1) on the outside of the casing. Take photos to document how the multisonde is placed and measure the distance from the top of the metal tube to the line between the blue and the black cover on the sonde. The cable from the datalogger to the multisonde runs inside the black conduit tube (7) and inside the metal-tube on the steel casing (9). Protect the open cable end before it is put through the metal tube in order to protect it from dirt. When everything is mounted and secured, connect to the multisonde via the DCP (Signal adapter) and the field laptop to test the communication. Start logging. Now the setup is ready to be submerged. Carefully move the heavy steel case down the cliff and slide it into the permanent metal rag that is fixed to the cliff/bedrock (6).

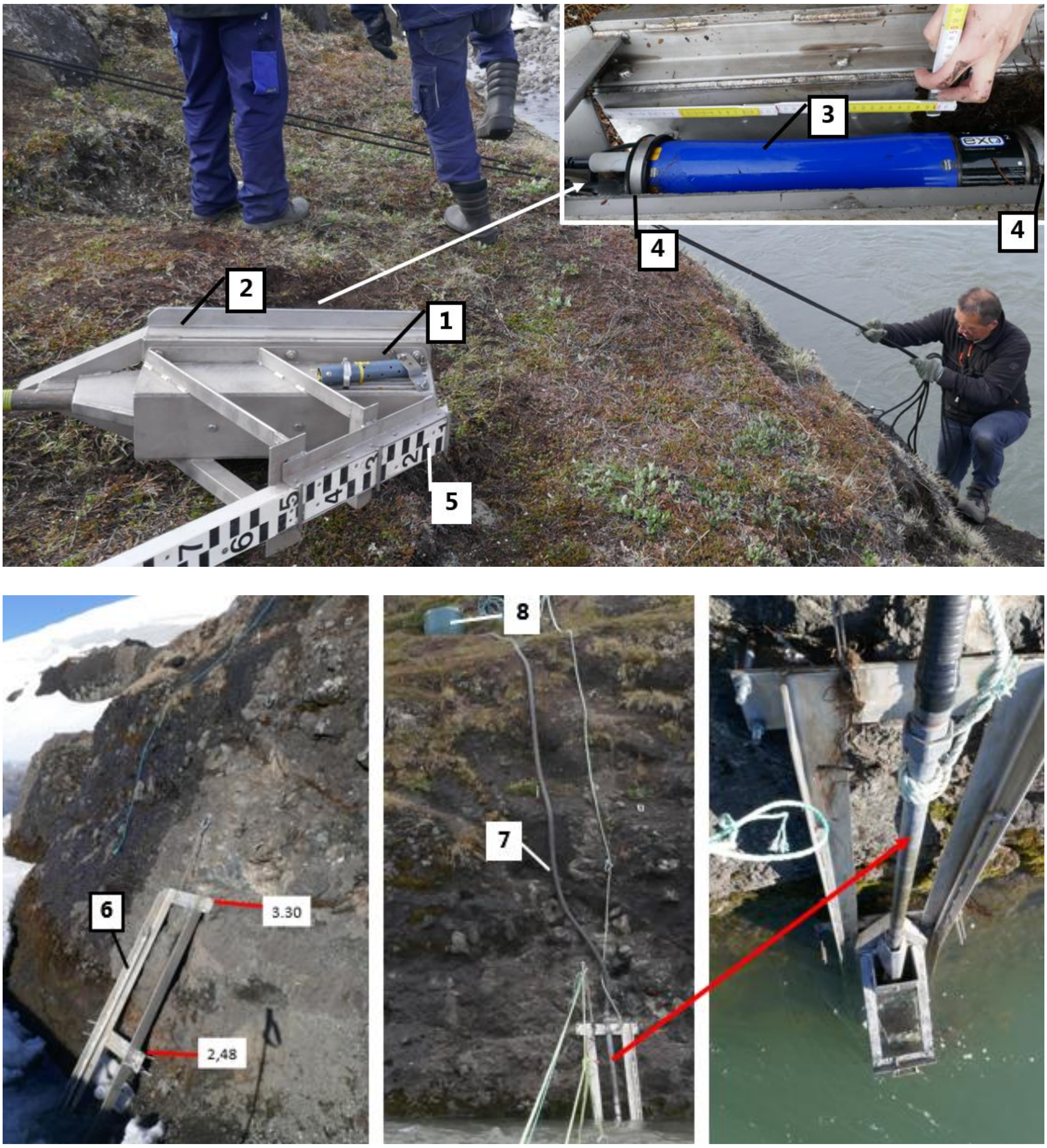
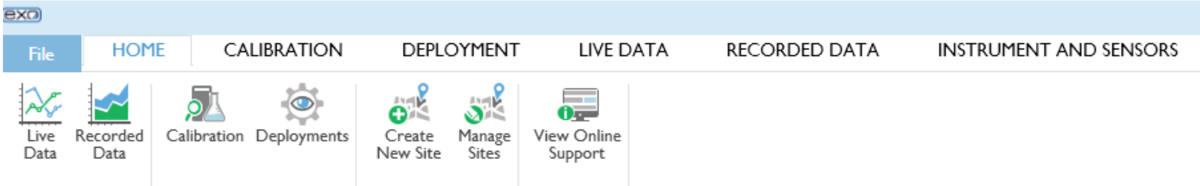


Figure 6.5. Fixed metalframe on the rockwall on the East side of the river crossing. The multi-sonde steel case slide into the frame when mounted.

6.2.3 Start deployment of EXO2 multisonde



Follow the EXO User’s Manual. Create a template with the following configuration

- Name: DiskoYYYY
- Logging interval: 15 min
- File name prefix: RE
- Site Name: RødeElv
  [Advanced]
- Logging mode: Normal
- System-wide averaging mode: Default
- Adaptive logging: OFF
- Samples per wipe: 1

Save and apply template to multisonde.

6.2.4 Offloading data from EXO2 multi-sonde

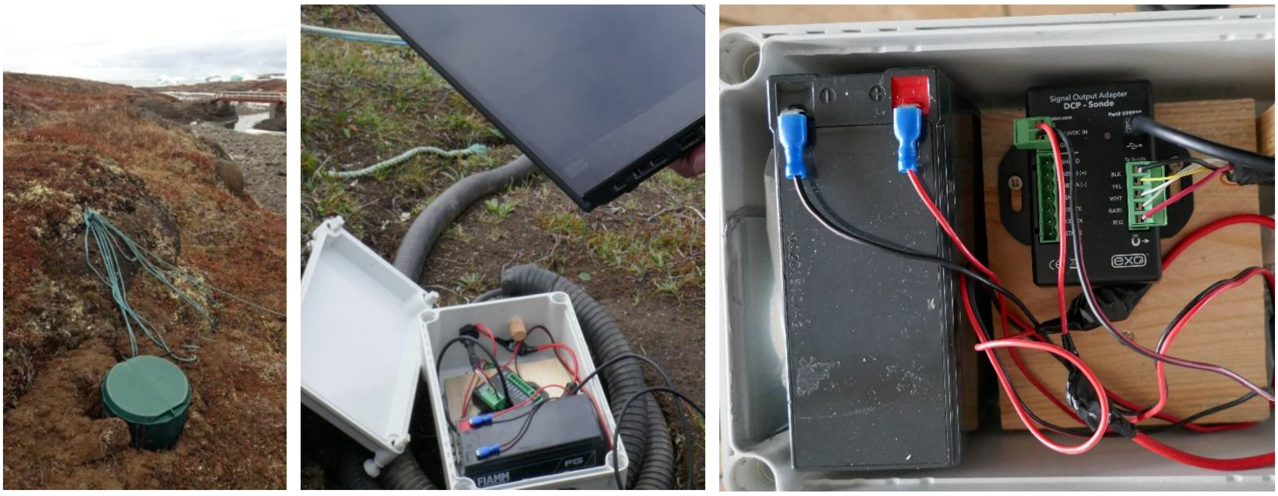


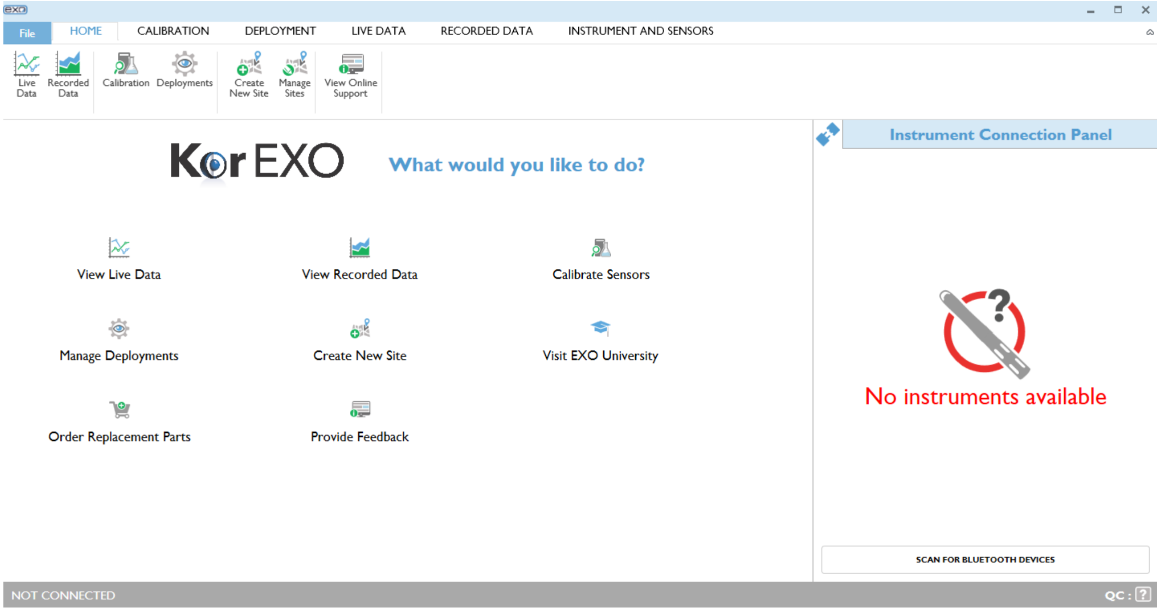
Figure 6.6 Location of external power and sonde communication.

Frequency:

Offload data every second week or every month -whenever it is possible. It is good to be able to check data
<u>Remember to note the exact date and time for offloading data.</u>

Procedure

1. Connect the computer to the Signal Output Adapter (DCP) in the grey enclosure.
2. Open KorEXO Software and connect to the multisonde in the **Instrument Connection Panel** on the right side of the Main Window.



3. Follow the KorEXO2 User's Manual
4. Export the recorded data file to CSV

Input of data to the GeoBasis database

Copy the retrieved data file to the GeoBasis directory (GeoBasis/Røde elv/KorEXO2 /Original data/filename).

Quick validation of data

- Open the data logger file in a spreadsheet.
- Create charts of all parameters and check that values look reasonable.
- Make sure the last logged value matches the actual time for downloading of data.
- Add any comments that can help in the final evaluation of data in a column called "Remarks" (e.g. color of the water, ice cover on riverbed and banks, precipitation….). Save this work-file in the GeoBasis directory (GeoBasis/Røde elv/YSI6820/Work data/filename).

Storage of the multi-sonde during winter

Please read section 5 about Maintenance and Storage in the EXO User's Manual and follow procedures about short-term storage and long-term storage for each sensor and the sonde.

- Remove the multi-sonde from the river before ice covers the sensors.
- Download all data and measure exact position of the sonde (relative to a fix point) before you remove it. Use an "ice-tuk" if you need to remove ice.
- Bring steel casing, multisonde and communication box to the station. Please make sure to cover all plugs and connectors carefully before the transport –to avoid dirt from entering.
- Perform test and calibration of the sensors before they are stored in the right solutions and with the original caps.

6.2.5 Launching of the water level logger (HOBO U20-001-04)

To communicate with the water level sensor (Figure 6.7) you need a computer with **HOBOware Pro software** and an Onset Optic USB Base Station (Base U-4) with a coupler (Coupler2-B) –see Figure 6.8. The logger measures absolute pressure. When deployed in the water the data need to be compensated for the barometric pressure. Make sure you have an extra sensor that measures barometric pressure. It is OK to use air pressure from the AWS2 weather station.

Figure 6.7 Water level sensor from HOBO Onset. The black cap is removed when communicating with the logger.

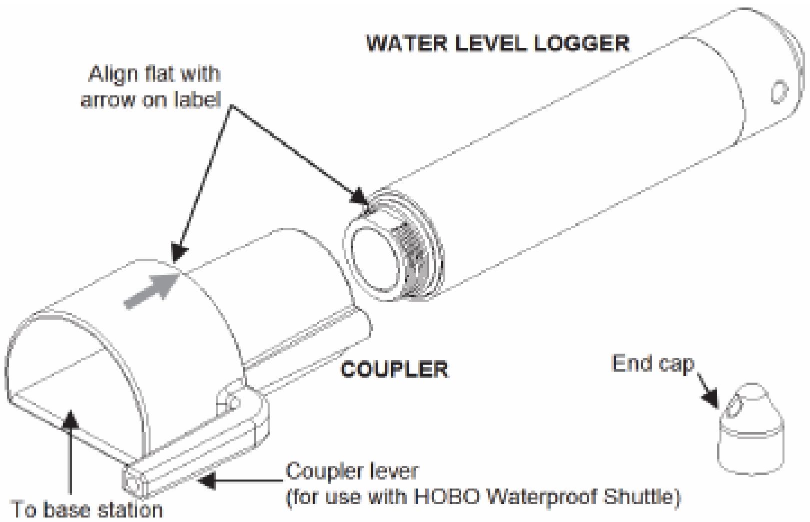
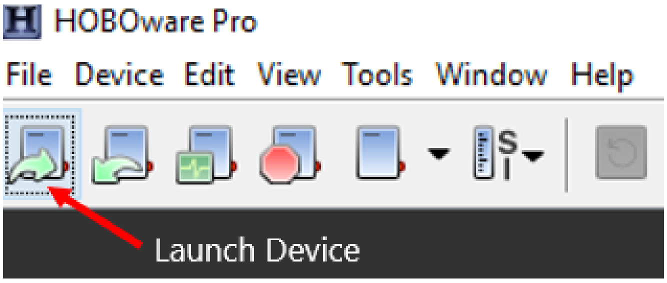


Figure 6.8 Optic Base Station (U-4) with coupler 2B.

Follow the HOBO U20 Water level logger Manual and HOBOware Users Guide

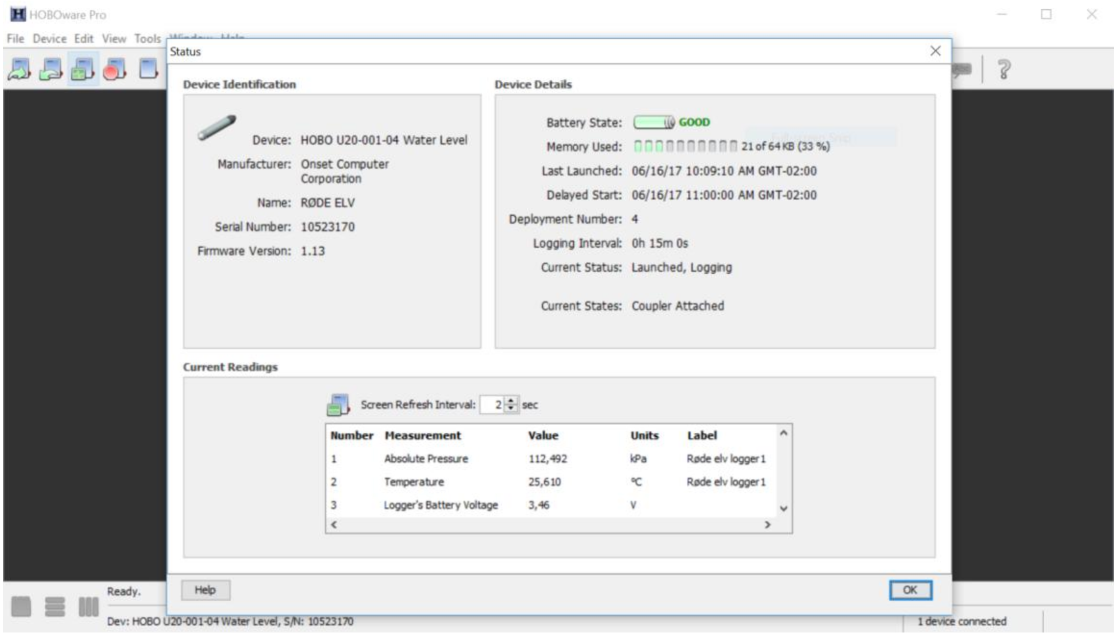
1. Unscrew the black plastic end cap from the logger by turning it counterclockwise.
2. Attach the coupler to the base station or shuttle
3. Insert the logger into the coupler with the flat on the logger aligned with the arrow on the coupler label. Gently twist the logger to be sure that it is properly seated in the coupler (it should not turn).
4. In the **HOBOware software** press [Launch Device] in the main panel



Settings:

- Logging interval: 15 min
- Time: UTC-2
- Sample logging
- Absolute Pressure
- Water temperature
- Battery voltage

5. Before you deploy the logger in the water: Connect the logger to the computer and verify the status. Click [Status] on the toolbar and observe that the absolute pressure is near the actual barometric pressure and the temperature is near the actual temperature and that the battery is 3.3 Volt (or above).



6. Place the water level logger inside the grey tube mounted on the steel rag (Figure 6.5).
7. Record deployment date and time in the field chart/log

6.2.6 Offload data from the water level logger (HOBO U20-001-04)

Follow the HOBO U20 Water level logger Manual and HOBOware Users Guide

1. Unscrew the black plastic end cap from the logger by turning it counterclockwise.
2. Attach the coupler to the base station or shuttle

3. Insert the logger into the coupler with the flat on the logger aligned with the arrow on the coupler label. Gently twist the logger to be sure that it is properly seated in the coupler (it should not turn).

Input of data to the GeoBasis database

Copy the retrieved data file to the GeoBasis directory (GeoBasis/Røde elv/HOBO/Original data/filename).

Quick validation of data

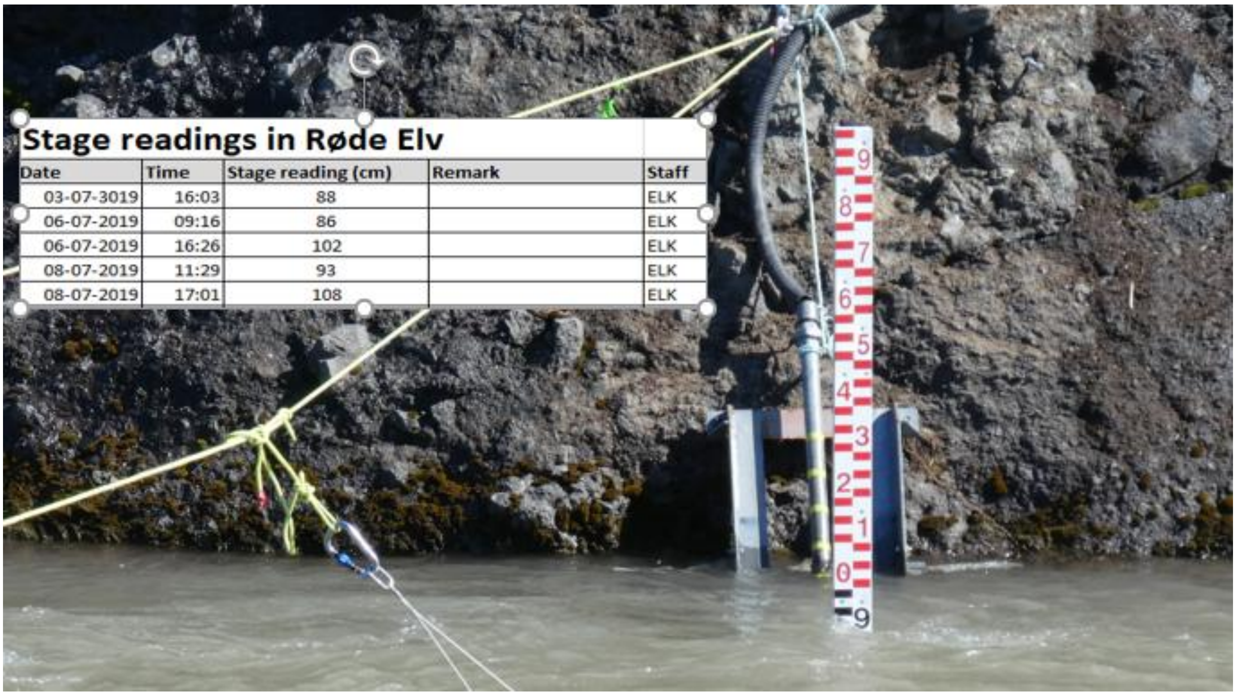
- Open the data logger file in a spreadsheet.
- Create charts of all parameters and check that values look reasonable.
- Make sure the last logged value matches the actual time for downloading of data.

Maintenance

Battery needs replacement every 5 years. Return the logger to Onset-company for battery replacement. Never try to open the logger. Only the black cap can be removed for communication purposes.

6.3 Manual water level

There is a stage level mounted at the river site when the steel rag is submerged. Please read the stage level and note date, time, and water level every time you pass the river (add results in the field chart/log). Alternatively, take a photo (close-up) of the stage level (make sure the labels are readable). The lower part of the stage is black and the upper one meter is red.



Stage readings in Røde Elv

Date	Time	Stage reading (cm)	Remark	Staff
03-07-3019	16:03	88		ELK
06-07-2019	09:16	86		ELK
06-07-2019	16:26	102		ELK
08-07-2019	11:29	93		ELK
08-07-2019	17:01	108		ELK

Figure 6.9. Stage level mounted in the river.

6.3.1 Fix points

There are some fixed points at both sides of the river (Figure 6.10).

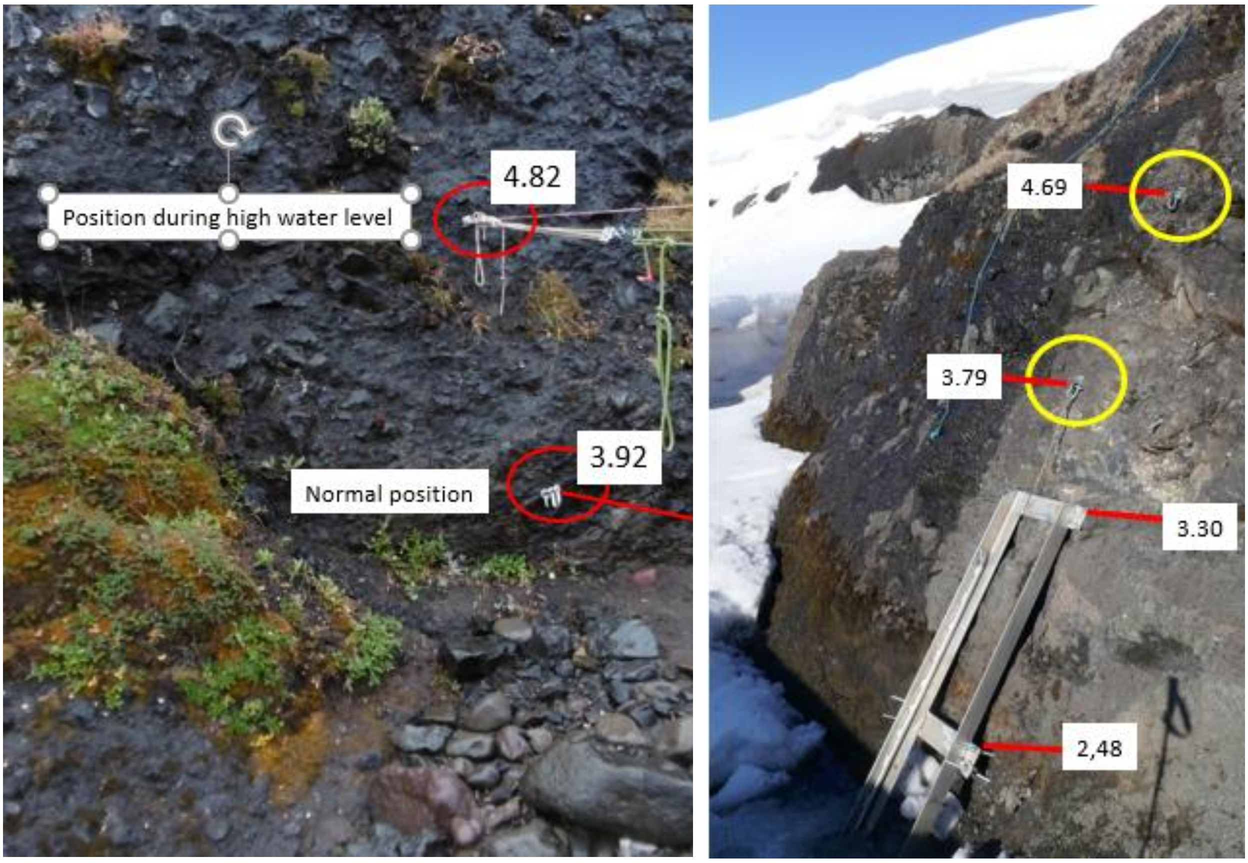


Figure 6.10. Fix points (meter above sea level) on the Western side of the river (left) and on the Eastern side of the river (right). The river crossing rope is attached to the lower eye bolt during normal water level (3.92 and 3.79). During very high water levels move the rope to the upper position (4.82 and 4.69).

6.4 Water discharge measurements

Manually measurements of the water discharge (Q) in Røde Elv are important in to establish a relation between water level (h) and discharge (Q) or to verify the existing Q/h relation for the river. When the water depth is less than 35 cm use the flow meter (Valeport). At water levels above 35 cm use the Q-liner2 catamaran (OTT).

Frequency

Manual discharge measurements must be carried out at least 5-10 times throughout the season after the riverbed and banks are free of snow/ice. This is done to verify the relation between water levels and discharges (Q/h) and to strengthen and improve the relation. Especially, measurements at very high and very low water levels are of interest to improve the span where the Q/h relation is valid.

Preparation of the river crossing

Right after the river break-up in spring a rope is mounted across the river profile. The rope is running in a loop between the rock walls on each side of the river. The rope is perpendicular to the flow of the water. The rope runs in a pulley. Attach the green rope to the eyebolt in the rock wall on the eastern side of the river and the eye bolt on the western side of the river (Figure 6.11, 6.12, 6.13). The distance between the two fixed points is approximately 25 m (Figure 6.12). <u>If the water level rises (if the water surface gets near the rope) the rope is moved upwards to the eyebolt above (Figure 6.10).</u>

Figure 6.11. The rope is running across the river in a loop. The white rope near the wall makes it easier to adjust and tighten the rope loop.

Attach a string with clearly visible markings for each meter next to the rope (Figure 6.12). **The western wall is point zero (0 m)** and measurements in the river must refer to this point. Attach a string/line with visible meter markings next to the rope (first mark is 1 m from the wall and so on).

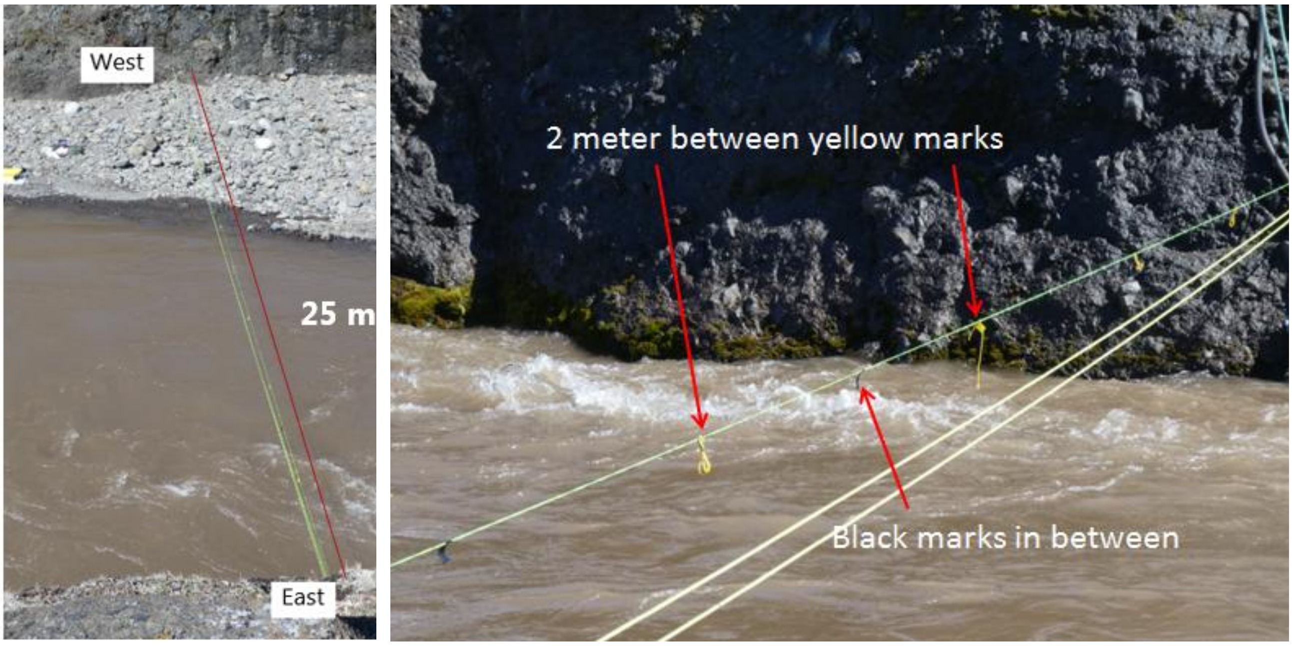
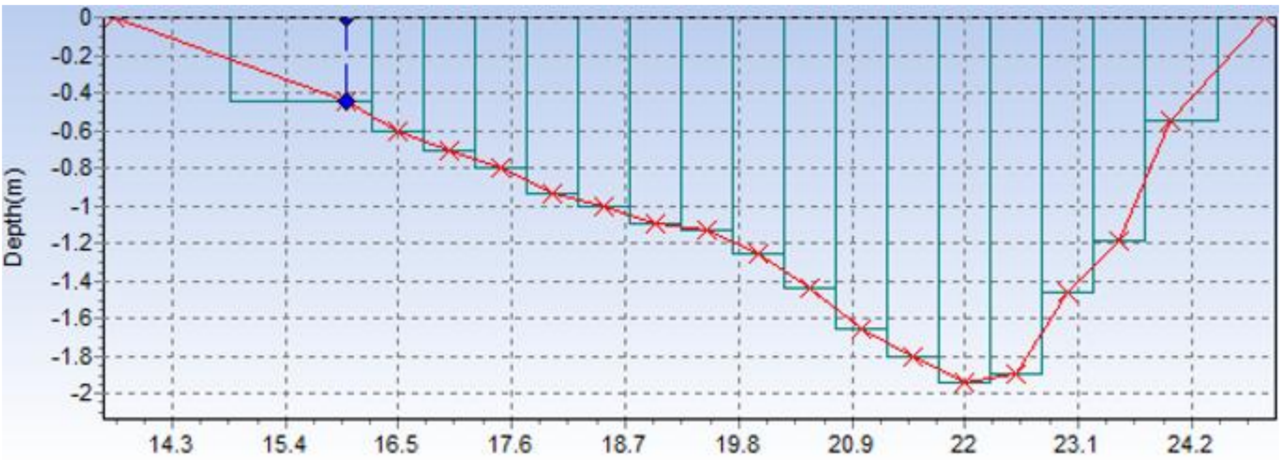


Figure 6.12. Mounting of the rope across the river. Next to the rope is a line with visible marks for every meter. Below is a topographic profile of the riverbed at the river cross profile from West to East.



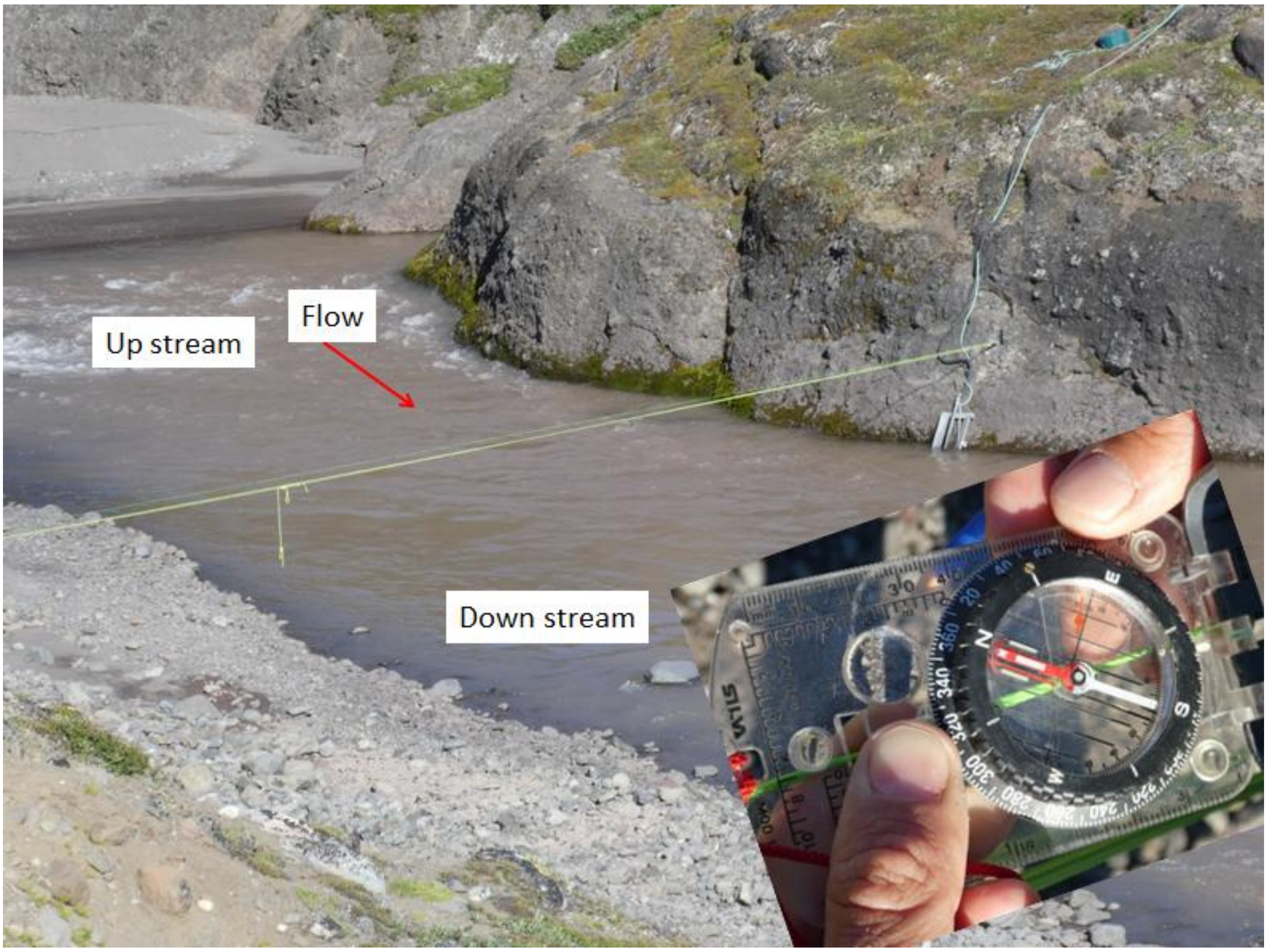


Figure 6.13. Discharge measurements are performed in a cross profile near the multisensor. The rope is attached to fixed anchors in the rock wall. The inserted photo shows the compass reading of the cross-rope.

6.4.1 Discharge using Q-liner

The Q-liner gives you detailed information about the river flow and provides an accurate bottom/bed profile. It is ideal for rivers 1-30 m wide and 0.3 - 10 m deep. The Q-liner uses Doppler technology to measure the vertical velocity profile. One of the big advantages is that the Q-liner is operated from the shore by Bluetooth communication.

Equipment to be used

- Field chart: Q-liner Disko
- Operating instructions Mobile River Discharge System OTT Q-liner 2
- Q-liner -located in the Lab building (Remember to charge batteries beforehand!!)
- PDA (Remember to charge!!)
- Folding rule or measuring tape
- Waders
- Camera

Procedure

1. Read the Manual “Operating instructions Mobile River Discharge System OTT Q-liner 2”.

2. Charge the Q-liner and the PDA.

3. Use the frame backpack to transport the Q-liner to the river. Wrap the soft sleeping pad around the Q-liner before it is securely strapped to the backpack.

4. Take photos from the photo points (Figure 6.14). Make sure the camera has the right date and time stamp!!

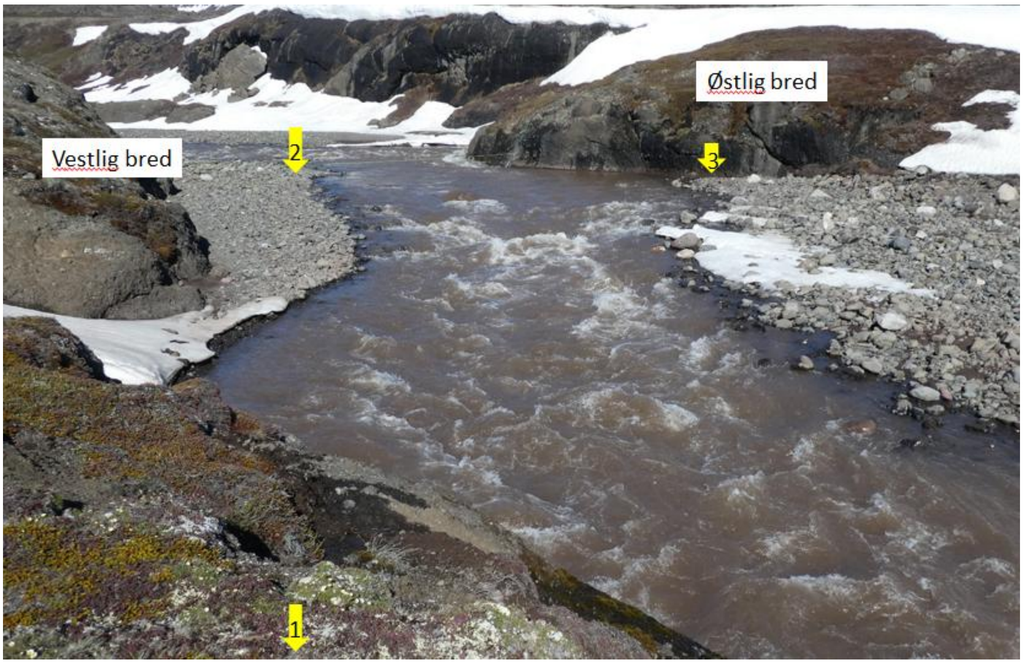


Figure 6.14. Photo points at the river site. For documentation

5. Take a close-up photo of the water table at the stage level (make sure you can read the stage). Photos can be a great help when evaluating the data).

6. Fill out the field chart before you start. It is very important to manually measure water level at the exact time. Refer to a known Fix point.

7. Check and note the depth for every half meter from the water line on the western bank to the first vertical. If they are between 10 and 35 cm you can use the flowmeter (from Valeport) to get value from this area.

8. Follow instructions given in the Q-liner-manual.

9. Start the Q-liner program on the PDA. From the Start menu select Q-liner_V3

Select Configuration > General settings

Save raw data: No
Power law: 6 (can be changed afterwards)
Units: metric
Frequency (kHz): 2000 (GeoBasis Qliner2 is 2000 kHz)

Use beam 3: YES (can be changed afterwards)

Use Compass: YES (can be changed afterwards)

Select Configuration > Communication

Serial port: COM 3

Baudrate: 9600

Timeout: Long (recommended in the manual)

Save entries with OK

Site name dropdown-list: select an earlier file from the same site

Select Settings > Repeat this measurement

Select Settings > Site

Site name: ReYYYYMMDD. If more than one measurement on the same day, add (1) (2)

Made by: <initials person 1>, <initials person2>

Position of first vertical:

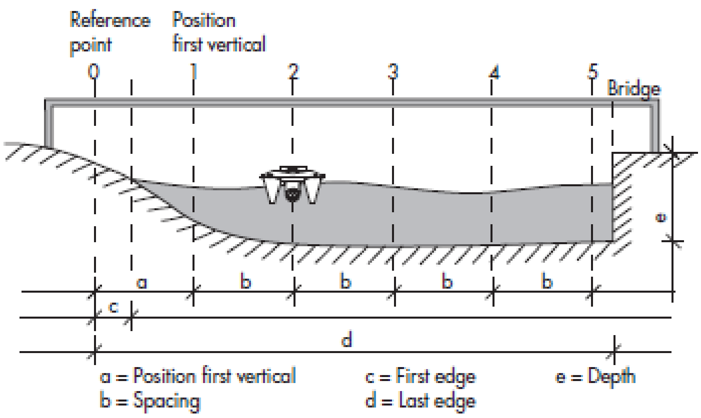
Spacing: spacing between individual verticals. 15-20 verticals are needed which means that we measure for each half meter at this site.

Line Heading: Orientation of the measuring profile

Edges, First: Distance from 0-point (rock wall on the western side to the water line

Edges, Last: Distance from 0-point to the water line on the eastern site (can be changed at the end of the measurement)

Factor: 0.7



Settings> Profiler

Maximum depth: Select a larger maximum depth than the actual. Use 3 m.

Cell size/blanking distance (vejledende værdier):

Cell size/blanking distance (vejledende værdier):

Vanddybde	Cell size	Blanking distance
0 - 1 m	**0.10 m**	0.05 m (use that under normal conditions)
1 - 2 m	0.20 m	0.05 m
2 - 5 m	0.30 m	0.10 m
> 5 m	0.50 m	0.10 m

Immersion depth: 0.06 m (vi har ikke selv målt, men den er givet i manual)

Measure time/Tx Power (vejledende værdier): Vi bruger 60 sekunder og max

Flow	Measure time	Tx Power
0 - 0.3 m/s	60 sek	min
> 0.3 m/s	30 sek	max
turbulent	60 sek	max

Switch on the Q-liner

1. Press **ON/OFF** on the operating display for 2 seconds. The blue LED blinks until the Bluetooth connection between the PDA and the Q-liner has been established. As soon as connection is established it lights continuously.

2. Check that the lid is closed correctly.

3. Attach the Qliner to the loop on the rope/wire (lock the carabin!!) Adjust length of rope so the Qliner is fixed in a way, so the boat has a horizontal position. If the rope is too short the tip of the boat points upwards.

4. Start the PDA (The "**On**"- button is in the lower left corner of the keyboard).

5. Place the Q-liner carefully in the water at the first position.

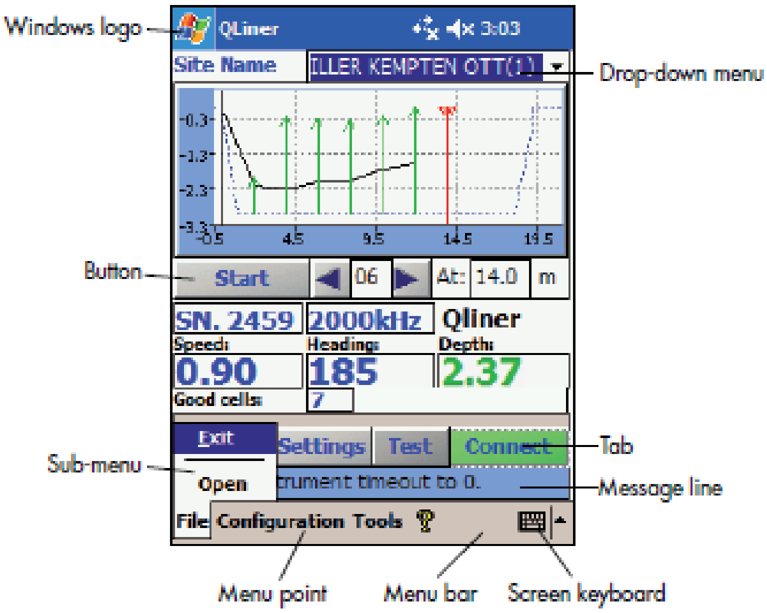
Measurement

1. Tap on the Windows logo to call the Start menu >Programs (select Qliner_V3).

2. Press Connect in the Qliner main menu.

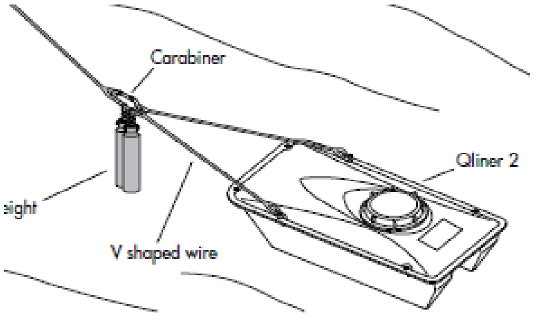
3. The system compares the date and time of the PDA and Qliner. If they differ you are asked whether data on the Qliner should be synchronized with that on the PDA. Make sure the PDA has correctly date and time settings (use UTC-2) and press OK to synchronize.

4. When the Q-liner has stabilized in the first position in the river –Press [**Start**]. After 10 seconds, speed and depth are shown in the main window.



5. A biiib sounds 10 sec before the measurement stops.

6. Note in the field chart if the Q-liner sits calmly in the water throughout the measuring period –and if the sensors are under water surface during the entire period. Especially, in the deepest part of the river (eastern side) the flow is strong, and waves may form on the surface of the water. To ensure that the Q-liner remains horizontal in the water it might be necessary to attach some extra weight to the cable in front (use rocks and robe)



7. If the speed and/or the depth vary a lot, it is possible to make an extra measurement in the same vertical. Accept the measurement > Press on the arrow next to [Start] to go one step back and enter the same vertical. Make a new measurement. Both measurements are saved.

8. Pull the cross-rope and move the Q-liner to a position half a meter further out (Figure 6.15). When it has stabilized in the new position press **Start.** Check that the distance on the PDA corresponds to the distance where the Q-liner is placed.

9. To end the measurement, select the sub menu: **Tools > End this measurement > End,** and after that **File > Exit**

10. Take the Q-liner out of the water. Switch off the Q-liner: Press **ON/OFF** for 5 seconds.

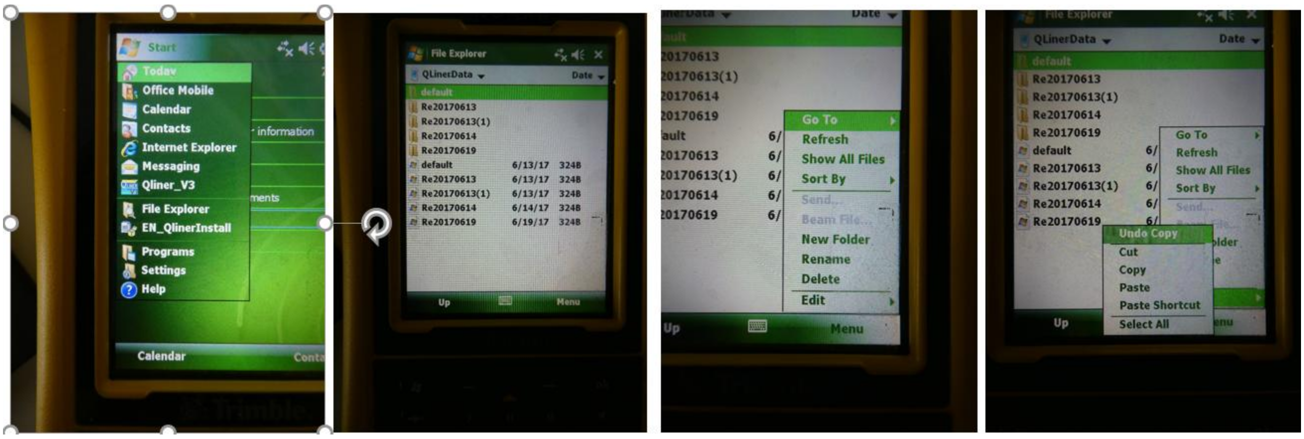
Figure 6.15. Discharge measurement carried out from the western side of the river crossing. The Q-liner boat is attached to the rope and can be pulled from one side of the river to the other. Measurements are carried out for each half meter.

Offloading data from the PDA

1. <u>It is important to transfer data from the PDA to the computer after each measuring day.</u>

2. Save data in the PDA folder **QlinerData**. The location of this folder is entered in **Configuration > General Settings.**

3. Insert a USB into the PDA. Tap on the windows logo and select **File Explorer** > **My Documents > QlinerData.** Select Menu in the lower right corner –**Edit > Select All.** Enter **Menu > Edit > Copy**. Press **Up** in the lower left corner until you see Harddisk in the upper panel. Press **Harddisk > Menu> Paste**



How to transfer data from the PDA to the computer

Input of data into the local database

- Export data from the PDA to the computer. All data from the folder QlinerData is saved in this directory: GeoBasis/Røde Elv/Discharge/Qliner2/YYYY

Quick validation of data

- Use the software OTT **Qreview** to process the data. Read the operating instructions for the Qreview software.
- Choose [File] [Open] and then the file you want to work with. Check that the velocity profile for each vertical look satisfactory. Suspicious measurements can be excluded: [Edit] -remove the tick mark under “valid” in the actual vertical.
- Press [Edit] – First edge position – correct the depth to the average depth between the last depth measured by flowmeter and the depth in the vertical first measured by Q-liner.
- When all corrections have been performed, press [Apply] and [Recalculate All].

Maintenance

- After the measurement, switch off the Q-liner.
- Clean/dry the Q-liner catamaran after every measurement and ensure that it is never packed in a wet or damp state.
- Make sure the O-ring in the lid looks nice and smooth, if any sediment/gravel has entered between the lid and the thread remove this and rub the O-ring with silicone

6.4.2 Discharge using electromagnetic Flowmeter

- If the water depth is between 10 and 35 cm for several meters, the discharge is measured by the Valeport flowmeter
- Read the Operation Manual for Model 801 Electromagnetic Flow Meter (Valeport). The model is with a Flat sensor and is suited for shallow applications.

Equipment to bring

- Orange suitcase with Flowmeter and Flat sensor
- Bring extra batteries (8 C cell batteries)
- Operation Manual (Valeport)
- 1.5-meter wading rod (50 cm pieces in the blue cover)
- Waders
- Field chart and pencil

Figure 6.16 Valeport flowmeter for manual discharge measurements at shallow depth –or in smaller streams where you can easily wade across the profile.

Procedure

1. Read the actual water depth on the stage level at the starting time

2. Measure for every half meter. Note the distance from the **0-point (the rock wall on the western side**)

3. If the water depth is below 25 cm, then do the measurement in 0.4 *depth (for 20 cm this means the sensor must be placed 8 cm above the riverbed)

4. If the water is above 25 cm, then do the measurement in 0.2 and 0.8 *depth (for 30 cm this means the sensor must be placed 6 cm above the riverbed and 24 cm above the riverbed

Settings:

- Correct date and time (UTC-2)

- Averaging period 60 seconds
- Fixed average

Input of data into the local database

- Export data from the Control Display Unit to the computer. Save data in the directory: GeoBasis/Røde Elv/Discharge/Flowmeter/YYYY/file

Quick validation of data

To be continued…..

6.5 River water chemistry

Water samples are collected manually in the river Røde Elv. Samples are collected for analysis of suspended sediment and for chemical analysis of the water composition. Calculation of suspended sediment in water samples is important to verify and supplement the turbidity readings from the Multisonde in the river. Also, the turbidity sensor has a certain range and sometimes the suspended load exceeds the maximum measured by the sensor. Total loads of solutes and transport of sediment from the terrestrial to the marine system can be calculated from the results of the analysis combined with the water discharge.

Figure 6.17. Sampling of water using depth integrating sampler USDH-48.

Parameters to be monitored

Sediment

- AS Suspended sediment concentration (GF/F filter)

Water

- AS Conductivity/ Specific conductivity
- AS Alkalinity
- IGN Chloride (Cl^-)
- IGN/BIO Nitrate (NO_3^-)
- IGN Sulfate (SO_4^{2-})
- IGN Calcium (Ca^{2+})
- ÏGN Magnesium (Mg^{2+})
- IGN Pottasium (K^+)
- IGN Sodium (Na^+)
- IGN Iron (Fe^{2+})
- IGN Aluminium (Al^{3+})
- IGN Manganese (Mn^{2+})
- BIO Ammonia (NH_4^+-N)
- BIO Dissolved total nitrogen (DTN)
- BIO Dissolved Organic Carbon (DOC)
- BIO Total Phosphorous (PO_4^{3-}-P)

*The prefix tells where the analysis is carried out. **AS**=Arctic Station, **IGN**=Department of Geosciences and Natural Resource Management, University of Copenhagen, **BIO**=Department of Biology (Terrestrial Ecology) University of Copenhagen*

6.5.1 Water sampling in Røde elv

Location

Water from the river is sampled by wading into the river from the western riverbank of the cross section/profile along the rope (Figure 6.17). If it is not possible to walk out in the river the sampling is performed from the shore. Pick a site where water flows freely and is well mixed.

Frequency

Water samples for suspended sediment analysis and water chemistry are collected every **3rd day at 4 pm**. During special events like heavy rainfall or sudden increase in sediment concentration or during flood situations sampling must be intensified to every second/fourth hour. Once or twice during the season a diurnal (24-hour) campaign must be performed –where water is sampled every second hour within 24 hour.

In 2025 we also sample for grainsize distribution (Thorbjørn Joest Andersen). See separate manual

Equipment to be used for water sampling

- Waders
- 2 empty clean plastic bottles with white lid (500 ml) (Figure 6.17, 6.18). Label with date and time. These are for suspended sediment sample and grain size sample
- 1 empty clean plastic bottle 500 ml labelled C. Label with date and time. This one is for water chemistry
- Depth integrating sampler (US DH-48) (see figure 6.18)
- Conductivity/temperature meter (WTW LF 340) (figure 6.19)
- Camera
- Field chart "River water"/Notebook and pencil

Procedure in the river

1. Walk/wade into the river along the river crossing rope to about 50 cm's water depth. Safety first. If the river is very turbulent or if there is ice on the river bottom, then sampling from the riverbank/near shore is fine.

2. Rinse the **C**- bottle with river water. Half fill the bottle –shake vigorously and discard the water before final filling. Fill the bottle completely, reaching upstream from the sampling point. Leave no airspace in the bottle to prevent degassing.

3. Place one of the 500 ml bottles (white lid) in the US DH-48 depth integrating device. Pull back the rear part of the device and place the bottle as shown in figure 6.18.

4. Wade into the river and collect the sample reaching upstream from the sampling point. Point the nose of the sampler upstream. Move the bottle/probe slowly at continuous speed vertically up and down through the water profile (do not touch the riverbed) until the bottle is full (c. 500 ml). Stop before you hit the riverbed to avoid bringing sediment from the riverbed into suspension.

5. Repeat step 3 and 4 with the second bottle with white cap.

Figure 6.18. Depth integrating sampler and bottle (left). How to place and remove the bottle by pulling the rear part back (middle). Depth integrating sampling in the river (right).

6. Record in situ conductivity and temperature by placing the sensor direct into the river (the probe must be completely covered) wait until temperature has stabilized and record results (figure 6.16).

7. Record general observations like snow and ice drift in the water, snow and ice conditions along the river and in the riverbed. Take photos of the river and the surroundings (useful when validating the data).

8. Bring samples to the lab at Arctic Station.

Figure 6.19. In situ measurement of conductivity and temperature in the river (left). The conductivity meter (right).

Procedure in the lab

1. Leave the 2 samples (white lid) for suspended sediment and grain size in the fridge for later. When more samples are collected, filter according to the procedure given in section 7.5. Make sure the bottles are labeled with date and time or if you use a numbering system on the bottles –make sure you keep track on the bottles and when each one was collected.

2. From the C- sample, prepare water samples for further chemical analyses carried out at BIO and IGN, University of Copenhagen (follow procedure in section 7.4).

3. Measure pH and alkalinity in a sub sample of the water collected for chemical analysis (C-bottle). Follow the procedure provided in section 7.2 and 7.3. Samples should have the same temperature as the pH buffer solutions.

Figure 6.20. Refrigerator and freezer in the Lab at Arctic Station

7 Procedure for water handling

From the moment, water samples are gathered they begin to deteriorate as a result of chemical and microbiological processes. Therefore, it is essential to carry out chemical analysis as soon as possible after collection and to store water cold and dark at prescribed temperatures.

7.1 Conductivity measurement

Conductivity must be measured within 36 hours in an unfiltered subsample. Conductivity is measured in the field or in the station laboratory using a conductivity instrument (WTW LF340).

For calibration, operation, cleaning and storage of the conductivity instrument see the Operation Manual for the actual instrument (GeoBasis/Manuals/WTW/)

1. Place the conductivity cell in the unfiltered water. Make sure that the cell is completely covered in water. Read conductivity and specific conductance expressed in µS/cm and record results in the field chart for river water, soil water or stream water, respectively. Read the actual temperature of the water sample and record it in the field chart. The conductivity of solutions is highly dependent on temperature.

7.2 pH measurement

The buffer solutions and the water sample must have same temperature when measuring. pH must be measured within 36 hours in an unfiltered subsample. pH is measured in the field or in the station laboratory using a pH-meter (WTW 3310). The same subsample can be used for both conductivity and pH measurements, but conductivity must be measured first. For calibration, operation, cleaning and storage of the pH-meter and sensor/electrode see the Operation Manual (GeoBasis/Manuals/pH-meter). Also read the document: Good pH measurements practice.pdf

Figure 7.1 Set-up for pH measurement.

- Calibrate the pH-meter before making measurements. A two-point calibration in buffer solution pH 7 and pH 4 is performed as close as possible to the sample temperature (follow the guide for the actual pH-meter and electrode used). Pour a sub sample of pH buffer into a 20 ml vial. Always discard the pH-buffer after use (only use the pH-buffer once). **How often do you need to calibrate the electrode**: For accurate measurements, at least daily. Always after changing electrode or after long storage, after replacement of electrolyte, cleaning of blocked diaphragm, rehydration or regeneration of electrode

1. Thoroughly rinse the electrode in de-ionized water and gently wipe drops of water with a lab tissue.

2. If an alkalinity test is made right after the pH measurement, the amount of water used for the pH analysis must be known.

3. Pour 50 ml of unfiltered water into a 100 ml beaker. Use the analytical balance/scale and record the exact weight of the water in the field chart.

4. Insert the probe into the unfiltered sample, shake gently to remove any trapped air bubbles and wait for the readings to stabilize (the probe takes time to equilibrate, depending on the ionic strength of the solution it may take several minutes).

5. Record the pH value and temperature of the water sample. If you want to measure alkalinity proceed from here to the next section and start titration on this water sample.

6. Always store the electrode in a storage solution (see operation manual for recommended storage solution) and keep it wet. A pH electrode can always be stored in its filling reference solution, both short term and long term. This solution is specific for each electrode, so make sure that you are using the correct solution (pH 4 or pH 7 buffer can be used for short term storage such as in between measurements to keep the membrane hydrated). Never store an electrode in deionized water as this will deplete the rich ion reference electrolyte from the reference chamber, increasing the electrical resistance.

7.3 Alkalinity measurement

Alkalinity must be measured within 36 hours in an unfiltered subsample. Alkalinity is measured in the laboratory by titration of a subsample, using 0.01 M HCl.

1. Pour 50 ml of unfiltered water in a 100 ml beaker. Use the analytical balance for this purpose and record the exact weight of the water in the field chart.

2. Place the beaker on the magnetic stirrer and add a clean magnet into the sample solution.

3. Insert the thoroughly rinsed and calibrated pH electrode into the sample (make sure that the rotating magnet does not touch the glass electrode). Record pH in the field chart when readings stabilize.

4. Fill the dispenser (Gilmont micrometer burette, 2 ml) with 0.01 M HCl (Figure 7.2). Tap to make sure you have no bubbles and adjust the amount to exactly 2 ml (the max amount that this dispenser can hold) Notice: To avoid contamination of the HCl never fill the dispenser directly from the bottle. Pour a small sample into a clean beaker/bottle and fill/refill from there.

Figure 7.2 Gilmont micrometer burette –the scale can be read with 3 decimals (left). 0.01 M HCl (middle). Set-up for titration (right)

5. Place the tip of the dispenser in the water and start to add 0.01 M HCl (slowly) into the sample. Give time for the pH-meter to adjust.

6. During the addition of HCl the water must be gently stirred to mix the solution (magnetic stirrer). Keep adding HCl slowly until pH in the sample solution drops to pH 4.5.

7. Record the volume of 0.01 M HCl added in the field chart.

7.4 Preparation of sub samples for further chemical analysis

Samples of river water need to be filtered prior to further analysis. Soil water samples have already been filtered through the ceramic suction probes (pore size: 2 microns). The filtering of samples should take place within 36 hours of collection.

Equipment to be used

- Syringe
- Disposable filter to attach to the syringe (0.2 µm, 0.45 µm)
- 2x 15 ml bottle/vial with label “RE_DD-MM-YYYY-HH-BIO”
- 1x 15 ml bottle/vial with label “RE_DD-MM-YYYY-HH -IGN”

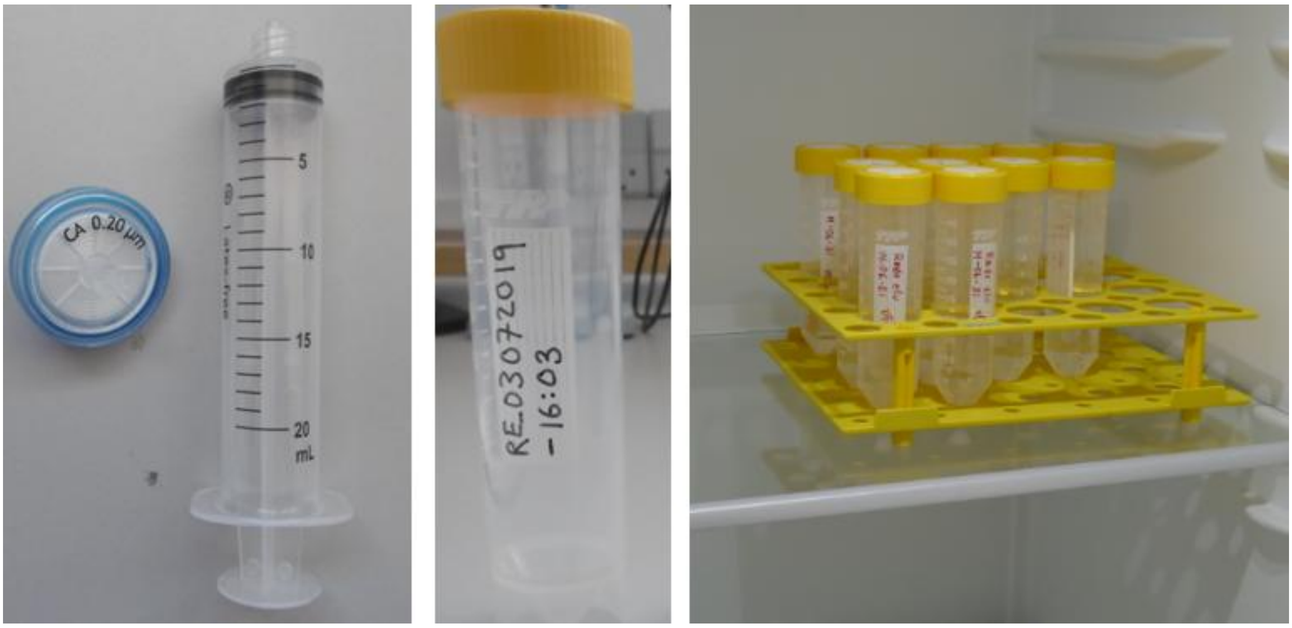


Figure 7.3. Equipment for filtering water samples. Filter and syringe and sterile yellow cap bottle.

Figure 7.4 The GeoBasis corner in the Lab (left). GeoBasis lab equipment (upper right). Scales in the AS lab (lower right).

Procedure

1. Filter two subsamples from the C-bottle for further chemical analysis. Label the bottles with date and time (River water is labelled: RE_ DDMMYYYY-HH:MM). Label both the bottle and the lid with a permanent marker.

2. Rinse the syringe with some of the sampled water –discard. Take a small sample and attach the filter on the syringe –and press to discard this water.

3. Take off the filter and fill the syringe with water from the sample. Attach the filter and press the sample through the filter and directly into the yellow cap bottle.

4. Filter the one to BIO through 0.45 µm filter and fill the bottle to 35 ml and store in the freezer

5. Filter the one to IGN through 0.2 µm and fill the bottle completely and store in the fridge

At the end of the season bring samples to IGN, Copenhagen (Contact: Charlotte Sigsgaard). Remember a **Survey license** whenever you bring samples out of Greenland (GeoBasis/Field season YYYY/Survey License).

7.5 Suspended sediment

The sample for suspended sediment needs to be filtered in the lab at the station. The samples can be stored in the fridge for a week before the filtration. It is often a good idea to filter more samples at one time.

Equipment to be used

- Water samples for suspended sediment
- Magnetic filter funnel (for 47 mm filter) + red plast cork
- Magnetic filter cup
- Whatman GF/F glass fiber filters. Retention diameter 0.7 µm. 47 mm in diameter.
- Filtering flask with plastic hose connection and socket (3L).
- Vacuum pump (see photo below)
- Spray bottle with filtered water
- Plastic petri plates (har fået tilsendt nogle forkerte, men de kan benyttes, hvis de tapes til. Så kan man lægge sin sølvpapir-pakke i denne skål). Sender en bedre løsning op
- Field chart “River water”
- Analytical scale
- Scale (up to 1 kg)

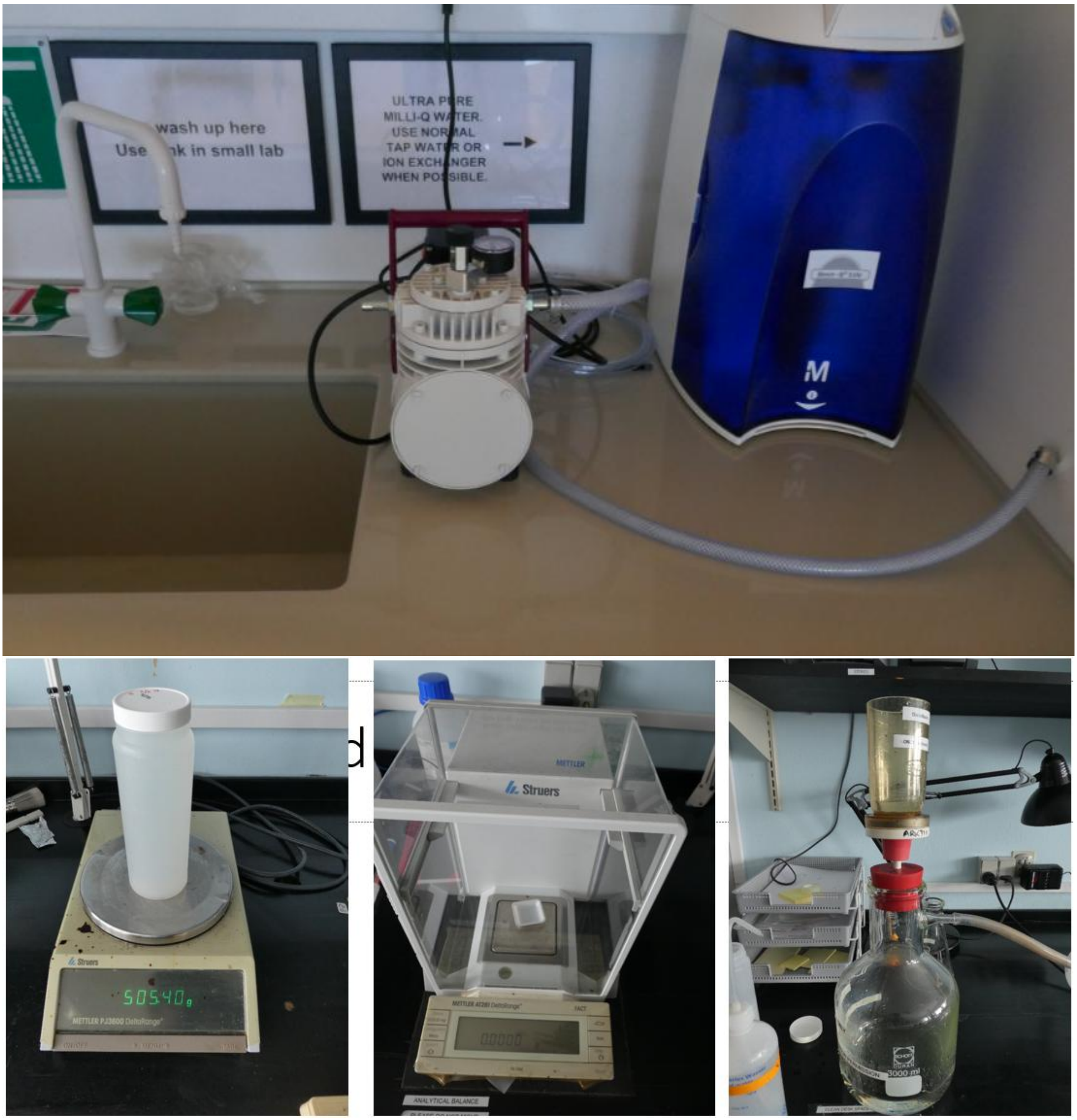


Figure 7.5 Vacuum pump. Scale to weigh the bottle when full and when empty (left). Analytical scale (middle). Set-up for filtering using the 3 L bottle (right).

Procedure

1. Dry/wipe the sample bottle (500 ml) on the outside and weigh the bottle with water (incl. the lid). Note the total weight in the field chart.

2. Mount the filter funnel into the red plastic cork that fits the 3 L glass filter flask.

3. Carefully place a dry GF/F filter on the analytical scale (use small clean tray –see figure) –note weight in the field chart

4. Carefully place the filter on the filter funnel and place the filter cup on the magnetic ring

5. Attach the tube from the vacuum pump to the hose on the flask. Make sure it is not at soft tube (then the tube walls will close when vacuum is applied) and make sure there is a filter in front of the intake to the pump (if water enters it damages the pump).

6. Pour water from the sediment bottle into the cup and start the pump. Keep adding water. When there is, only about 1-2 cm left in the bottle then shake the bottle well and pour the last sample into the filter cup. If the sample contains large amounts, of suspended sediment, it might be necessary to use more than one filter –otherwise the filter clocks. Just remember to weigh all dry filters and note the weight in the field chart (give them numbers).

7. Use a spray bottle with filtered water to spray the last sediment out of the sample bottle. There might still be some left inside. You can add as much water as needed.

8. Use the spray bottle to wash down sediment grains from the sides of the filter cup.

9. Note the weight of the empty bottle and lid in the field chart. <u>If you filter several samples then remember to keep an eye on the water level in the 3 l filter flask. Empty the flask before the water approesach the hose connection. Some of the filtered water is collected into the spray bottle.</u>

10. Carefully, remove the filter with sediment to a small tray of tin foil (figure 7.6). Note date and time on the tin foil next to the filter. When all samples are filtered, move the tin foil tray with filters into the plastic box and carefully place the lid on the box. Go to the dry oven and place the tin foil tray inside (do not use an oven with fan and ventilation since filters will be blown around). Dry the filters at 65°C for at least 3-4 hours.

11. Switch off the oven and let the filters cool down to room temperature inside the oven.

12. Move the filters (placed inside the box for transportation) to the analytical scale. Weigh the filter on the analytical scale and note the weight in the field chart.

Figure 7.6 Tray of tin foil with filters -always transport them in the closed box (left). Weigh filter on a small tray on the analytical scale (right).

Figure 7.7 Place the dried filter in the plastic petri box. Note date and time label on the outside.

- Note: RE_DD-MM-YYYY-HH on the outside of the plastic box. Place the dried filter inside the plast box. Can be stored at room temperature

- At the end of the season bring all filters to IGN, Copenhagen (Contact: Charlotte Sigsgaard)

Input of data to local database

Write results from the field charts in the template 'River water_YYYY' (DiskoBasis/River water) and save data in (GeoBasis/River water/Data_work).

Quick validation of data

Create charts of all parameters from the field chart to verify that outliers or typos are found.

7.6 Grain size distribution (see separate manual)

Follow the procedure given in the manual from Thorbjørn and use the pre-weighed Millipore filters from Thorbjørn.

7.7 Bottle and vial washing

All containers (beakers and bottles) and equipment used in the laboratory must be thoroughly rinsed before use. Follow the instructions given at Arctic Station: Wash in a laboratory cleaning agent. Rinse two times in de-ionized water. Shake to remove drops of water and let equipment air dry in the rack next to the wash.

Figure 7.8 Drying rags and tap with de-ionized water (red handle).

8 Phenology/vegetation monitoring

Plant phenology and NDVI are examined and monitored both in Østerlien and at the Snow fence site in Blæsedalen in some non-manipulated control plots next to the snow fences.

Parameters to be measured

- NDVI
- Plant phenology photos

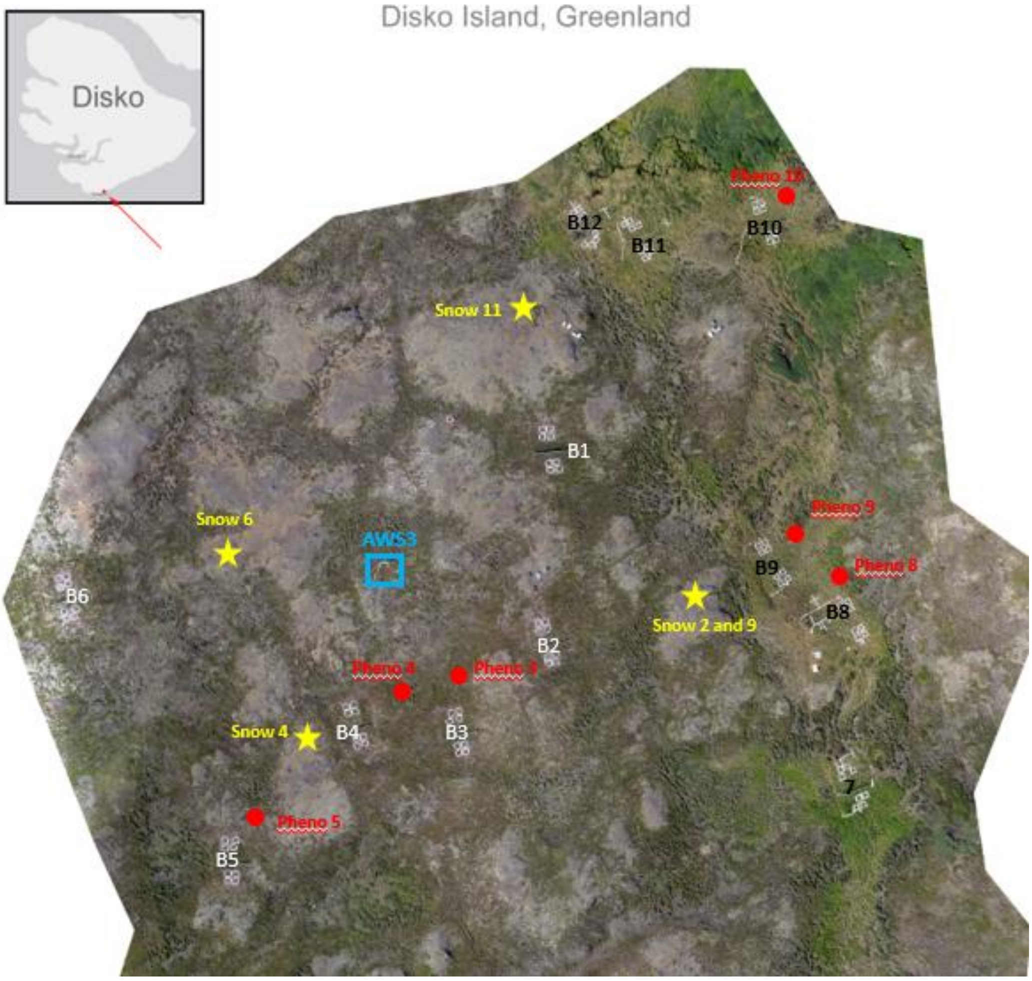


Figure 8.1 CENPERM experimental site in Blæsedalen. Snow fences B1-B12. Yellow stars: Snow camera sites. Red dots: Pheno camera sites. Blue square: Automatic weather station AWS3. Camera positions in Table 1.

Table 1

Snowfences	Capital	Facing	Project	Elevation	Lat_dec deg	Long_dec deg
Snow 2	A	West	CENPERM	87	69.26529	-53.46369
Snow 4	I	East	CENPERM	92	69.26487	-53.46789
Snow 6	K	West	CENPERM	97	69.26556	-53.46853
Snow 9	B	East	CENPERM	87	69.26528	-53.46374
Snow 11	F	East	CENPERM	94	69.26640	-53.46584
Phenology						
Pheno 3	G	Down	GEM	87	69.26495	-53.46581
Pheno 4	H	Down	GEM	88	69.26512	-53.46662
Pheno 5	J	Down	GEM	86	69.26461	-53.46891
Pheno 8	C	Down	GEM	88	69.26539	-53.46227
Pheno 9	D	Down	GEM	89	69.26556	-53.46247
Pheno 10	E	Down	GEM	92	69.26684	-53.46271

8.1 NDVI monitoring

Automatic measurements/calculations of NDVI are based on SKYE light sensors recording RED and NIR. Lightsensors/radiometer are mounted both at AWS2 in Østerlien and at AWS3 in Blæsedalen.

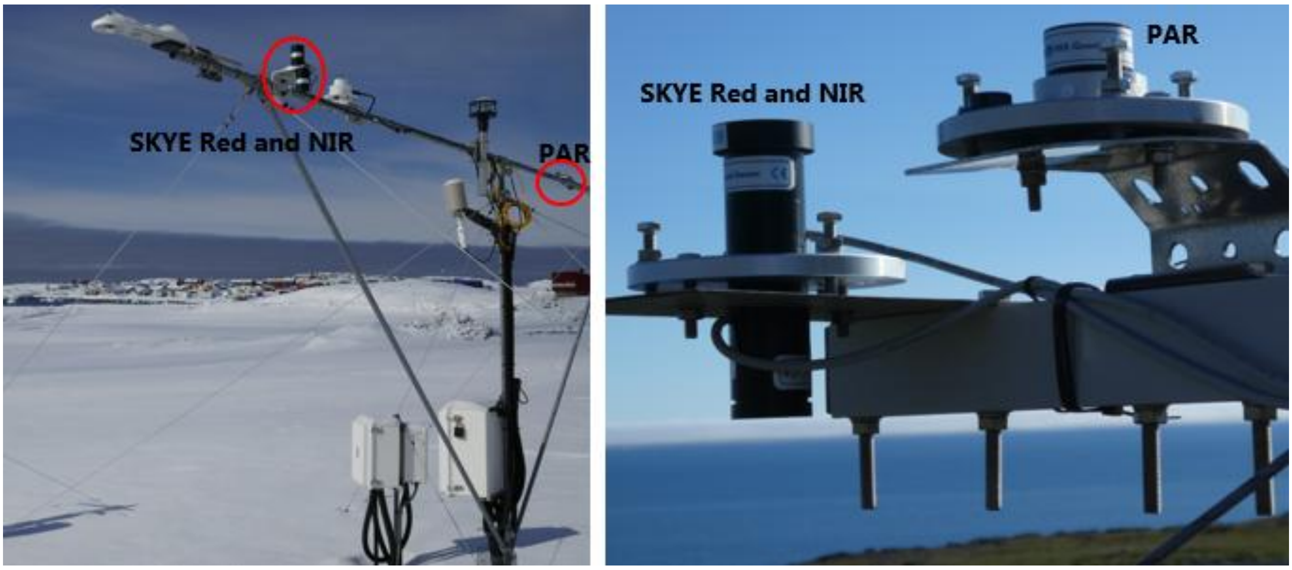


Figure 8.2. PAR sensor and RED and NIR sensor sensors on AWS2-Østerlien (left) and AWS3-Blæsedalen (right).

8.1.1 Manual NDVI monitoring

Next to all snow fences at the experimental site in Blæsedalen, there are plots where plant phenology is studied. At 6 out of 12 sites there are cameras installed for automatic photo monitoring.

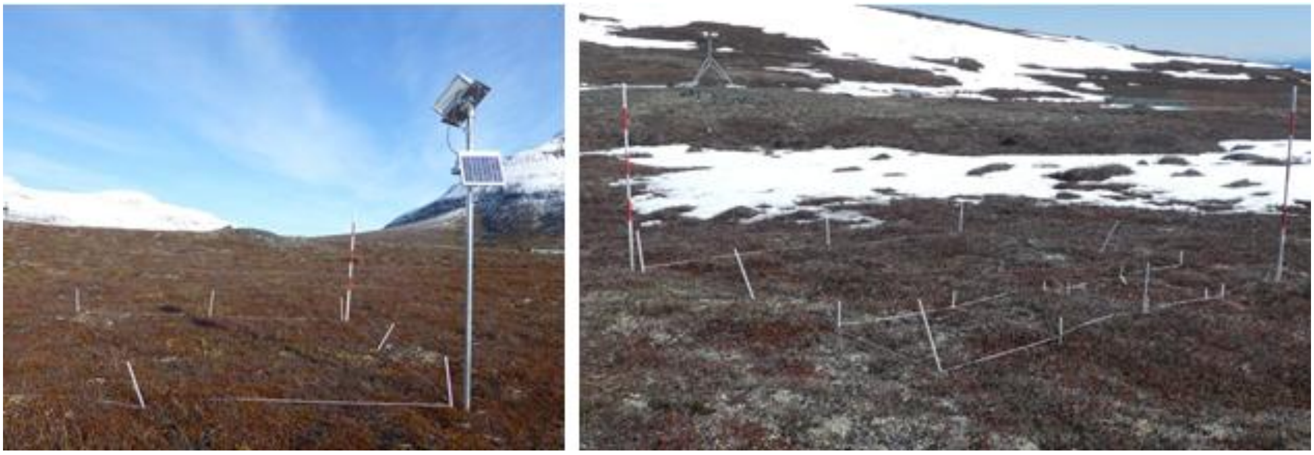


Figure 8.3 Set-up in one of the Phenology plots with camera (left) and without camera (right)

Location

The 12 plots where manual NDVI are measured are located next to the fences. Cameras are located next to Block 3, 4 and 5 (in the Dry) and next to 8, 9 and 10 (in the Wet). The position of each plot is given below.

Frequency

Once a week in all 12 plots

Equipment to use

- SKYE: Red/Far-red Sensor with 1.2m cable and connector for Meter + SKR100 Ratio Measuring Unit for SKR 110
- Camera
- Field chart + pen
- GPS

Procedure

1. Find the plot. Go to the SE-corner and start to measure from this corner. Cameras are installed in the SE corner of the plot. Positions are given in decimal degrees. Never walk inside the plot.

ID	Location	Decimal degrees	
Blok 1	Phenology plot SE-corner	69.26599	53.46528
Blok 2	Phenology plot SE-corner	69.26525	53.46540
Blok 3	Phenology plot SE-corner	69.26496	53.46642
Blok 4	Phenology plot SE-corner	69.26500	53.46750
Blok 5	Phenology plot SE-corner	69.26453	53.46882
Blok 6	Phenology plot SE-corner	69.26556	53.47050
Blok 7	Phenology plot SE-corner	69.26469	53.46231
Blok 8	Phenology plot SE-corner	69.26529	53.46228
Blok 9	Phenology plot SE-corner	69.26551	53.46310
Blok 10	Phenology plot SE-corner	69.26677	53.46305
Blok 11	Phenology plot SE-corner	69.26673	53.46432
Blok 12	Phenology plot SE-corner	69.26674	53.46490

2. The display meter switches on when the sensor is attached (plug in) and switches off when the sensor is removed. Switch between RED and Far RED on the button on the left side (see explanation on the back of the meter display). The button on the right side enables you to switch range.

3. The plot is marked with white strings. It is a square with 4 sub-squares in the western side. Be careful to keep the sensor clean.

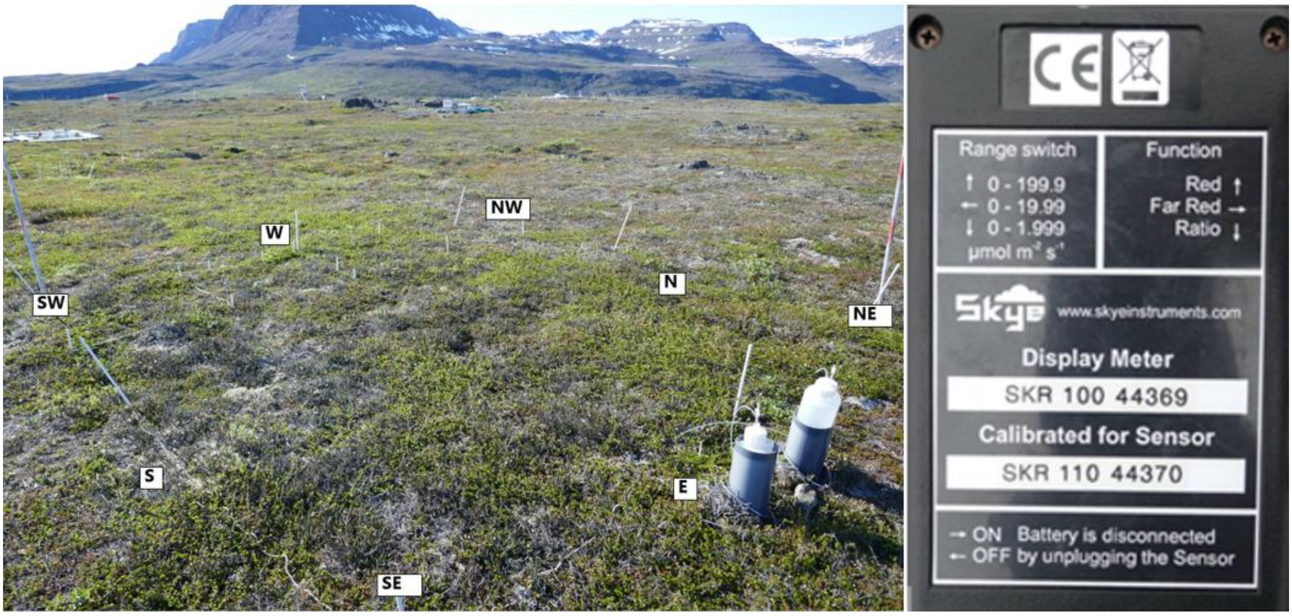


Figure 8.4 Photo of the vegetation plot from the SE-corner (left) and the back of the meter (right).

4. Point the side of the sensor with the white spot towards the vegetation/ground. Hold the sensor orthogonal to the vegetation approximately 50-60 cm above the vegetation. Stand outside the plot and reach in with your arm. Avoid shading. Also, be aware of the shade from the camera set-up.

5. Read RED and FarRED and note (write in field chart –or use your phone for recordings). Make three measurements. If out of range, toggle the switch on the right side.

6. Move to the S position (Figure 8.4) and repeat the measurement (3 replicates). Then to SW, W, NW, N, NE, and E.

7. When measurements have been performed from all sites leave the sensor in the box and find the camera.

8. Stand in the SE corner and take photos covering the plot from a position where you reach up with the camera and point it like the installed camera (see photos). Before you take the photos take a snapshot of a paper where you write Block 1-12 so you know from which plot the next photos are from.

Figure 8.5 Measurement from one of the corners -must be performed closer to the vegetation approximately 50-60 cm above surface (left). Set-up in the WET area (right) Indsæt nyt billede med korrekt position over vegetation

8.1.2 Automatic NDVI photo monitoring

Photos from the automatic cameras can also be used for estimation of NDVI –variation in vegetation greenness. 6 cameras were installed at the Snowfence site in Blæsedalen (experimental site by CENPERM) in the summer 2014. The 6 cameras in Blæsedalen are located at some non-manipulated control plots next to the snow fences.

Location

There are three cameras located in the dry area just north of Block 3, 4 and 5 and three cameras located in the wet area next to Block 8, 9 and 10 (see Figure 8.1 for positions).

Cameras are mounted in a waterproof box on a 2 m pole. The camera is looking down at the vegetation from a steep angle. Photos are captured three times a day 9:00, 12:00 and 15:00. Photos are saved on a 16 GB SD card.

Frequency

Offload cameras at least twice a year (May and September)

Procedure

- Offloading camera -see procedure in section 4.2.1 and see separate manual
- Camera settings -see procedure in section 4.2.2 and see separate manual

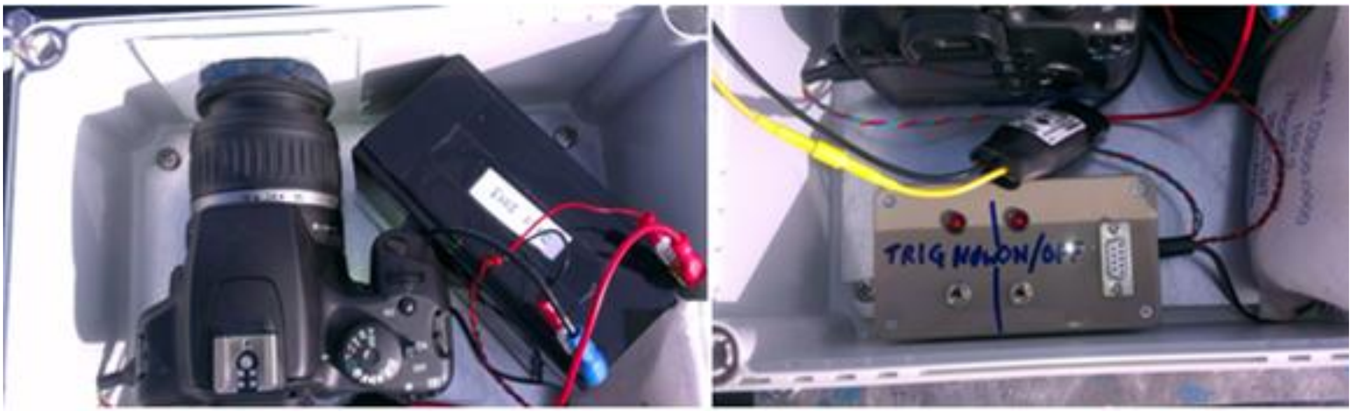


Figure 8.5. Inside a camera box. There are two switches on the trigger box (right). The switch closest to the serial port is the ON/OFF button and the other switch is the Trigger button. The Trigger button turns on the camera, so it captures a photo and then the camera switches off automatically. The ON/OFF button turns on the camera and leaves the camera ON for an hour (no photos captured). The camera is ON even though it turns into sleep mode.

8.1.3 Procedure to power the internal camera battery

To avoid the camera losing the internal date and time the internal battery may need to be powered. This is done by pushing the Trigger button (Figure 8.5). This will leave the camera ON for an hour where it receives power from the external battery supply. Make sure the voltage on the external battery is OK. Afterwards the right date and time are entered in the camera menu.

9 Precipitation

Liquid precipitation are measured/registered at the automatic weather stations AWS3 and AWS4 by tipping bucket precipitation sensors. This means that only liquid/rain is registered. Snow is only registered if it melts inside the collector –but most of it will be wiped out of the collector by the wind. ClimateBasis measures precipitation 700 meter from Arctic Station at their Meteorological station on Teleøen where precipitation is measured in heated models with screens which gives a better estimate of the total precipitation (Figure 1.1).

9.1 Automatic registration

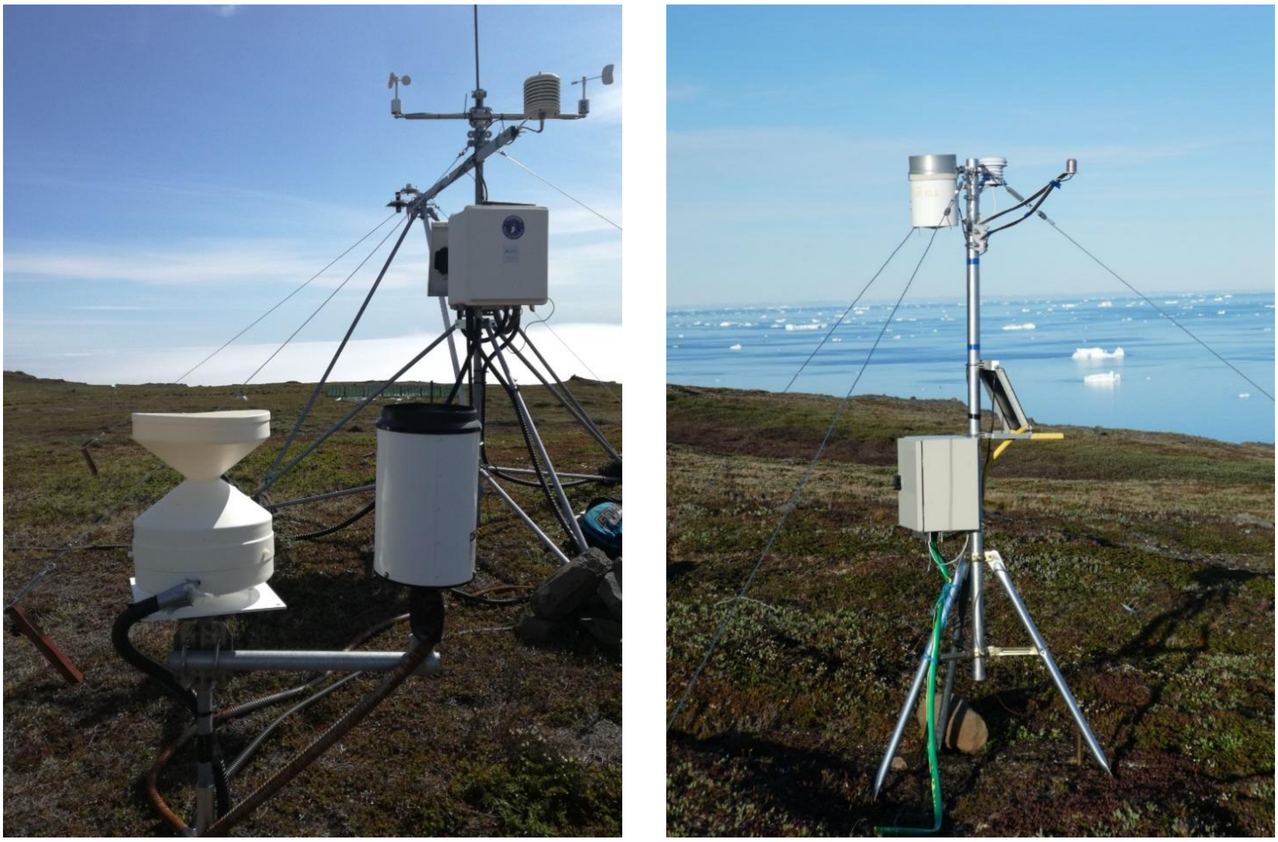


Figure 9.1 Tipping bucket at AWS3 (left) and AWS4 (right).

9.2 Precipitation bulk sampling

Precipitation is sampled in Blæsedalen next to AWS3. The rain sampler is specially designed to store collected precipitation for weeks or even months without evaporation. At the moment, GeoBasis collects water for a pilot study (by Per Ambus) where the total bulk precipitation is collected every month. Subsambles are later analyzed for isotopic composition (GNIP-project). If there is more precipitation than needed by this project (300 ml), GeoBasis collects subsamples for chemical analysis.

Figure 9.2 Cummulative integrated sampler (totalizer) (left) and AWS3 weather station (right).

Location

The precipitation collector is mounted next to AWS3 in Blæsedalen (see section 2.3)

Frequency

Precipitation is collected every first day of the month (May, June, July, August, September, October). In periods with heavy rain it might be necessary to collect more often to avoid spill-over from the 3 liter bottle.

Procedure in the field

1. Bring out a clean empty 3 L bottle with green lid (stored in the Basis-room and labelled precipitation). Ensure the bottle is rinsed with deionized water.

2. Carefully remove/unscrew the bottle inside the metal cover (reach from below). Place the clean lid from the spare bottle on the bottle with the precipitation inside

3. Inspect the green funnel for debris and dust and clean with some deionized water

4. Mount the new bottle inside the cover (reach in from below). Ensure that the tube from the sampler enters the bottle.

5. Bring the precipitation to the lab at Arctic Station.

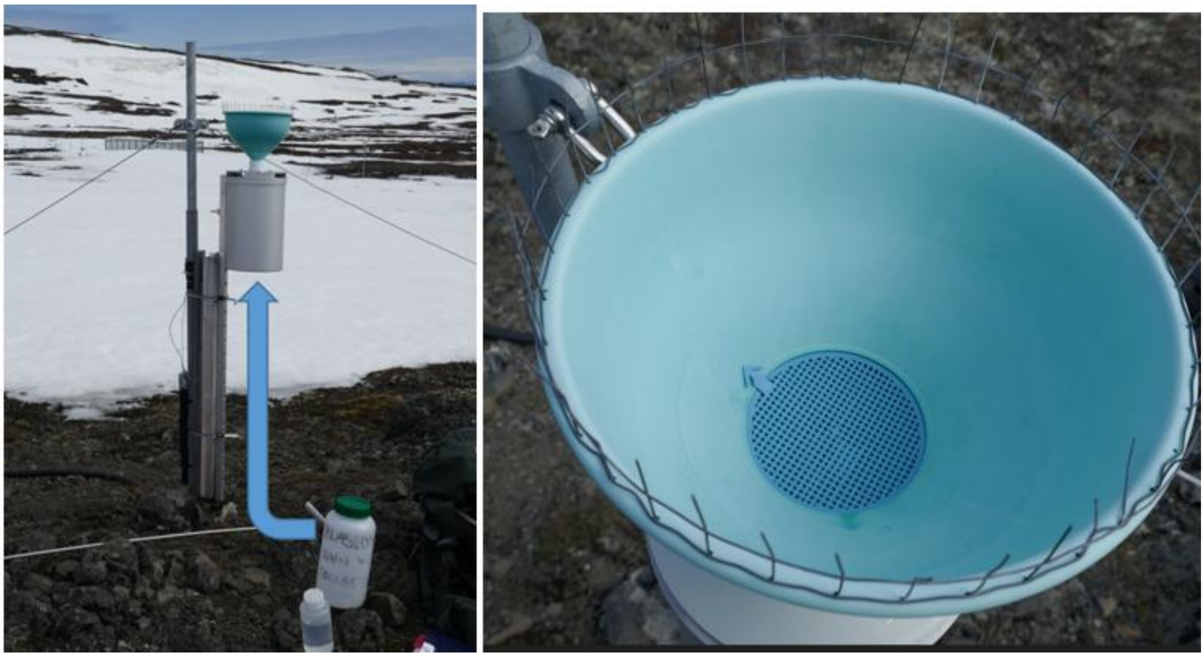


Figure 9.2 Cummulative integrated sampler (totalizer).

Procedure in the lab

1. Weigh the total sample and bottle on the scale. Note weight in the field chart. Remember to weigh the empty bottle.

2. Depending on the amount of water, pour sample into a 60 ml brown glass bottle (GNIP). Store dark and cold (refrigerator).

3. If the total amount of water exceeds 100 ml, then measure conductivity in the excess water (see procedure in section 7.1).

4. Filter the excess water (follow section 7.4) into 2x15 ml vials (labelled Precip: DD-MM-YYYY-BIO). Leave space for expansion due to freezing (fill only 4/5) and 1x15 ml (labelled Precip: DD-MM-YYYY-IGN) –leave in fridge.

5. If there is more water left, then pour a 30-50 ml subsample into a 100 ml beaker (weigh sample). Carry out pH measurement and titration on this unfiltered sample (follow section 7.2 and 7.3)

Appendix

Appendix 1: Instrumentation of installations

Appendix 2: GPS positions of all GeoBasis installations/sites

Appendix 3: Geomorphological map

APPENDIX 1 Installations

AWS-2_Østerlien: Mux (Datalogger CR1000x SN: 15354) Position dec deg: : 69.25355 N, -53.51414 W, 25 m asl

Log interv	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Sensor height	Installed
30 min	Soil surface temperature	°C	Temperature sensor P1	100K6A1A		BetaTherm	0 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-10 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-20 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-30 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-40 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-50 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-60 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-70 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-80 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-90 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-100 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-110 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-120 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-130 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-140 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-150 cm	August 2012
30 min	Soil surface temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	0 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	10 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	20 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	30 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	40 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	50 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	60 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	70 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	80 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	90 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	100 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	110 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	120 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	130 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	140 cm	August 2012
30 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	150 cm	August 2012
30 min	Soil surface temperature	°C	Soil temperature probe	pt 107		Campbell Scientific	0 cm	August 2012
30 min	Soil surface temperature	°C	Soil temperature probe	pt 107		Campbell Scientific	0 cm	August 2012
30 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-5 cm	July 2013

30 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-10 cm	July 2013
30 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-20 cm	July 2013
30 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-30 cm	July 2013
30 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-50 cm	July 2013
30 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-100 cm	July 2013
30 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-150 cm	July 2013
30 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-200 cm	July 2013
30 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-250 cm	July 2013
30 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-350 cm	July 2013

AWS-2_Østerlien: Met (Datalogger CR1000X SN: 15354) Position dec deg: : 69.25355 N, -53.51414 W, 25 m asl

Log interv	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Sensor height	Installed
30 min	Battery minimum Voltage	Volts						August 2012
30 min	Reference temperature	°C						August 2012
30 min	Snow depth	m	Sonic ranging sensor	SR50A-EE	13533	Campbell Scientific	282 cm	January 2023
30 min	Air temperature	°C	Temperature and humidity senso	HMP155A	TO770303	Vaisala	308 cm	Sep 2022
30 min	Relative humidity	%	Temperature and humidity senso	HMP155A	TO770303	Vaisala	308 cm	Sep 2022
30 min	Air pressure	mbar	Air pressure sensor	CS100	4953201	Campbell Scientific	250 cm	August 2012
30 min	Wind speed_max	m/s	2D Wind sonic	Windsonic4	22130108	Campbell Scientific	338 cm	Sep 2022
30 min	Wind speed_avg	m/s	2D Wind sonic	Windsonic4	22130108	Campbell Scientific	338 cm	Sep 2022
30 min	Wind dir_avg (geographic north)	°	2D Wind sonic	Windsonic4	22130108	Campbell Scientific	338 cm	Sep 2022
30 min	Short wave radiation_up	W/m2	Net radiometer	CNR4	120765	Kipp & Zonen or Campbell	311 cm	Sep 2021
30 min	Short wave radiation_down	W/m2	Net radiometer	CNR4	120765	Kipp & Zonen or Campbell	311 cm	Sep 2021
30 min	Long wave radiation_up	W/m2	Net radiometer	CNR4	120765	Kipp & Zonen or Campbell	311 cm	Sep 2021
30 min	Long wave radiation_down	W/m2	Net radiometer	CNR4	120765	Kipp & Zonen or Campbell	311 cm	Sep 2021
30 min	Netto short wave radiation	W/m2	Net radiometer	CNR4	120765	Kipp & Zonen or Campbell	311 cm	Sep 2021
30 min	Netto long wave radiation	W/m2	Net radiometer	CNR4	120765	Kipp & Zonen or Campbell	311 cm	Sep 2021
30 min	Netto radiation	W/m2	Net radiometer	CNR4	120765	Kipp & Zonen or Campbell	311 cm	Sep 2021
30 min	Albedo		Calculated					Sep 2021
30 min	Instrument temperature	Kelvin	Net radiometer	CNR4	120765	Kipp & Zonen or Campbell		Sep 2021
30 min	Skye temperature	°C	Net radiometer	CNR4	120765	Kipp & Zonen or Campbell		Sep 2021
30 min	Ground temperature	°C	Net radiometer	CNR4	120765	Kipp & Zonen or Campbell		Sep 2021
30 min	RED	µmol/m2/s	Skye radiation sensor	1840 D/X, 1840	49138, 4913(	SKYE	311 cm	July 2018
30 min	NIR	µmol/m2/s	Skye radiation sensor	1840 D/X, 1840	49138, 4913(	SKYE	311 cm	July 2018
30 min	RVI -Relative Vegetation Index		Calculated			SKYE	311 cm	July 2018
30 min	NDVI- Normalized Differential Vegetation Index		Calculated			SKYE	311 cm	July 2018
30 min	Soil moisture	vol%	Soil moisture and temperature pr	SM300		Buch Holm, Delta-T Devices	-10 cm	August 2012
30 min	Soil moisture	vol%	Soil moisture and temperature pr	SM300		Buch Holm, Delta-T Devices	-20 cm	August 2012

30 min	Soil moisture	vol%	Soil moisture and temperature pr	SM300		Buch Holm, Delta-T Devices	-30 cm	August 2012
30 min	Soil heat flux	mV	Hukseflux Soil heat flux plates	HFP01SC-10	002653	Campbell Scientific	-5 cm	August 2012
30 min	Soil heat flux	mV	Hukseflux Soil heat flux plates	HFP01SC-10	002654	Campbell Scientific	-5 cm	August 2012
30 min	UV-B	W/m2	Analog UV Biometer	501 DA	23147	Solar light	311 cm	June 2017
30 min	PAR	µmol m2 s-1	PAR Quantum sensor	SQ-110	21759	SolData Instruments	311 cm	June 2017
30 min	PAR	µmol m2 s-1	PAR Quantum sensor	Li-190	Q121619	Licor	300 cm	Sep 2024
30 min	PAR	µmol m2 s-1	PAR Quantum sensor	Li-190	Q121620	Licor	300 cm	Sep 2024
30 min	Soil temperature	°C	Soil moisture and temperature pr	SM300		Buch Holm, Delta-T Devices	-10 cm	July 2018
30 min	Soil temperature	°C	Soil moisture and temperature pr	SM300		Buch Holm, Delta-T Devices	-20 cm	July 2018
30 min	Soil temperature	°C	Soil moisture and temperature pr	SM300		Buch Holm, Delta-T Devices	-30 cm	July 2018
30 min	Soil temperature		Soil moisture and temperature pr	SoilVue10	2654	Campbell Scientific	300 mm	Sep 2022
30 min	Soil temperature		Soil moisture and temperature pr	SoilVue10	2654	Campbell Scientific	300 mm	Sep 2022
30 min	Soil temperature		Soil moisture and temperature pr	SoilVue10	2654	Campbell Scientific	300 mm	Sep 2022
30 min	Soil temperature		Soil moisture and temperature pr	SoilVue10	2654	Campbell Scientific	300 mm	Sep 2022
30 min	Soil temperature		Soil moisture and temperature pr	SoilVue10	2654	Campbell Scientific	300 mm	Sep 2022
30 min	Soil temperature		Soil moisture and temperature pr	SoilVue10	2654	Campbell Scientific	300 mm	Sep 2022
30 min	Soil moisture		Soil moisture and temperature pr	SoilVue10	2654	Campbell Scientific	300 mm	Sep 2022
30 min	Soil moisture		Soil moisture and temperature pr	SoilVue10	2654	Campbell Scientific	300 mm	Sep 2022
30 min	Soil moisture		Soil moisture and temperature pr	SoilVue10	2654	Campbell Scientific	300 mm	Sep 2022
30 min	Soil moisture		Soil moisture and temperature pr	SoilVue10	2654	Campbell Scientific	300 mm	Sep 2022
30 min	Soil moisture		Soil moisture and temperature pr	SoilVue10	2654	Campbell Scientific	300 mm	Sep 2022
30 min	Soil moisture		Soil moisture and temperature pr	SoilVue10	2654	Campbell Scientific	300 mm	Sep 2022

AWS-3 Blæsedalen (Datalogger CR1000 SN: E11500) Position dec deg: 69.265525N, -53.467324W, 90 m asl

Log interv	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Sensor height	Installed
30 min	Battery voltage_min	Volts						July 2013
30 min	Battery voltage_max	Volts						July 2013
30 min	Reference temperature	°C						July 2013
30 min	Air temperature	°C	Temperature and humidity senso	CS215		Campbell Scientific	220	July 2013
30 min	Relative humidity	%	Temperature and humidity senso	CS215		Campbell Scientific	220	July 2013
30 min	Wind speed_avg	m/s	Anemometer	A100R	15068	Campbell Scientific	230	July 2018
30 min	Wind gust_max	m/s	Anemometer	A100R	15068	Campbell Scientific	230	July 2018
30 min	Wind direction	Deg	Windvane	W200p		Campbell Scientific	230	July 2018
30 min	PAR	µmol/m2/s	PAR sensor, Quantum sensor	SKP215	SNo.42581	Campbell Scientific	200	July 2013
30 min	RED_avg	µmol/m2/s	Skye radiation sensor	SKR 1800	'42809/LT428	SKYE	200	July 2013
30 min	NIR_avg	µmol/m2/s	Skye radiation sensor	SKR 1800	'42809/LT428	SKYE	200	July 2013
30 min	RVI_avg		Calculation					July 2013

30 min	NDVI_avg		Calculation					July 2013
30 min	Soil moisture	vol%	Soil moisture and temperature pr	SM300		Buch Holm	-5	July 2013
30 min	Soil moisture	vol%	Soil moisture and temperature pr	SM300		Buch Holm	-10	July 2013
30 min	Soil moisture	vol%	Soil moisture and temperature pr	SM300		Buch Holm	-20	July 2013
30 min	Soil moisture	vol%	Soil moisture and temperature pr	SM300		Buch Holm	-40	July 2013
30 min	Precipitation	mm	Precipitation gauge	ARG100		Campbell Scientific	80	August 2014
30 min	Precipitation	mm	Precipitation gauge	52202	8757	YOUNG	80	June 2017
30 min	Soil temperature	°C	Soil moisture and temperature pr	SM300		Buch Holm	-5	July 2018
30 min	Soil temperature	°C	Soil moisture and temperature pr	SM300		Buch Holm	-10	July 2018
30 min	Soil temperature	°C	Soil moisture and temperature pr	SM300		Buch Holm	-20	July 2018
30 min	Soil temperature	°C	Soil moisture and temperature pr	SM300		Buch Holm	-40	July 2018

AWS-4 Blæsedalen (Datalogger HOBO U30 10038120) Position (dec deg : 69,27282N, -53,45363W, 240 m asl

Log interv	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Sensor height	Installed
30 min	Water Content/Soil moisture	m3/m3	Soil probe	ECO5(S-SMC-M003		Onset, HOBO	-5 cm	June 2018
30 min	Water Content/Soil Moisture	m3/m3	Soil probe	ECO5(S-SMC-M003		Onset, HOBO	-20 cm	June 2018
30 min	Solar Radiation (Shortwave incoming)	W/m2	Pyranometer	S-Lib-XXXX	10005264	Onset, HOBO	200 cm	August 2015
30 min	Air Pressure	mbar	Barometric Press	S-BPB-XXXX	10005913	Onset, HOBO		August 2015
30 min	Soil temperature	°C	Temperature sensor	S-TMB-XXXX		Onset, HOBO	-5 cm	June 2018
30 min	Soil temperature	°C	Temperature sensor	S-TMB-XXXX		Onset, HOBO	-20 cm	June 2018
30 min	Rain	mm	Rain sensor	S-RGB-M002	10008694	Onset, HOBO	200 cm	July 2019
30 min	Air temperature	°C	temperature and humidity sensor	S-THB-XXXX		Onset, HOBO	200 cm	June 2018
30 min	Relatvie humidity	%	temperature and humidity sensor	S-THB-XXXX		Onset, HOBO	200 cm	June 2018
30 min	Voltage	mV		91-U30-CVIA-XX	10037763	Onset, HOBO		
30 min	Batt, V (LGR S/N: 10038120)	V				Onset, HOBO		July 2021

EC1_Gas flux Østerlien Position (dec deg: 69.25355N , -53.51414 W, 25 m asl

Log interv	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Sensor height	Installed
	Horisontal windspeed, u	m/s	3D-Sonic anemometer	Gill HS-50		Gill Instruments, Lymington	205 cm	Sep 2019
	Horisontal windspeed, v	m/s	3D-Sonic anemometer	Gill HS-50		Gill Instruments, Lymington	205 cm	Sep 2019
	Vertical windspeed, w	m/s	3D-Sonic anemometer	Gill HS-50		Gill Instruments, Lymington	205 cm	Sep 2019
	CO2-concentration	ppm	Gas Analyzer	Li-7200_RS	72H-0892	LiCOR, Nebraska, USA	205 cm	Sep 2019
	H2O-concentration	ppt	Gas Analyzer	Li-7200_RS	72H-0892	LiCOR, Nebraska, USA	205 cm	Sep 2019
	Instrument temperature inside	°C	Gas Analyzer	Li-7200_RS	72H-0892	LiCOR, Nebraska, USA	213 cm	Sep 2019

	Instrument temperature Outside	°C	Gas Analyzer	Li-7200_RS	72H-0892	LiCOR, Nebraska, USA	213 cm	Sep 2019
	Instrument pressure	kPa	Gas Analyzer	Li-7200_RS	72H-0892	LiCOR, Nebraska, USA	213 cm	Sep 2019
			Analyzer Interface Box (October 2	Li-7550		LiCOR, Nebraska, USA	120 cm	Sep 2019
			Analyzer flow module (October 2(	Li-7200-101		LiCOR, Nebraska, USA	120 cm	Sep 2019
	Processing and synchronization		SmartFlux		smart2-0044(	LiCOR, Nebraska, USA		Sep 2019

RE (436-2) Røde elv (YSI EXO2-21E102873) Position dec deg : 69.25362N, -53.49823 W, 5 m asl

Log interv	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Sensor height	Installed
15 min	Water level	m	Multiparameter sonde	EXO2	21E102873	YSI		July 2022
15 min	pH		Multiparameter sonde	EXO2	21E102873	YSI		July 2022
15 min	Specific conductivity	µS/cm	Multiparameter sonde	EXO2	21E102873	YSI		July 2022
15 min	Water temperature	°C	Multiparameter sonde	EXO2	21E102873	YSI		July 2022
15 min	Salinity	ppt	Multiparameter sonde	EXO2	21E102873	YSI		July 2022
15 min	Turbidity	NTU	Multiparameter sonde	EXO2	21E102873	YSI		July 2022
15 min	Water pressure/temperature	kPa	Water level sensor	U20-001-04		HOBO, Onset		

T1 (HOBO U23-003) Position dec deg: 69.27300 N, -53.47940 W, 125 m asl

Log interv	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Sensor height	Installed
30 min	Air temperature	°C	Temperature sensor	U23-003		Onset, HOBO	200 cm	2014
30 min	Soil/ground surface temperature	°C	Temperature sensor	U23-003		Onset, HOBO	-1 cm	2014

T2 (HOBO U23-003) Position dec deg: 69.28909 N, -53.43282 W, 830 m asl

Log interv	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Sensor height	Installed
30 min	Air temperature	°C	Temperature sensor	U23-003		Onset, HOBO	200 cm	2023
30 min	Soil/ground surface temperature	°C	Temperature sensor	U23-003		Onset, HOBO	-1 cm	2023

T3 (HOBO U23-003) Position dec deg: 69.27671 N, -53.45710 W, 400 m asl

Log interv	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Sensor height	Installed
30 min	Air temperature	°C	Temperature sensor	U23-003		Onset, HOBO	200 cm	2017
30 min	Soil/ground surface temperature	°C	Temperature sensor	U23-003		Onset, HOBO	-1 cm	2017
30 min	Air temperature	°C	Temperature sensor	U23-003		Onset, HOBO	200 cm	2021
30 min	Soil/ground surface temperature	°C	Temperature sensor	U23-003		Onset, HOBO	-1 cm	2021

T4 (HOBO U23-003) Position dec deg: 69.25127 N, -53.49897 W, 1 m asl

Log interv	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Sensor height	Installed
30 min	Air temperature	°C	Temperature sensor	U23-003		Onset, HOBO	200 cm	2017

30 min	Soil/ground surface temperature	°C	Temperature sensor	U23-003	Onset, HOBO	-1 cm	2017

Appendix 2: GeoBasis Disko GPS Positions

ID	Location/Element	Elevation	Decimal degrees	
T4	Delta -Røde elv	1	69.25127	-53.49897
T1	Mast Pjeturssons morraine	125	69.27300	-53.47940
AWS-4	Weather Station Skarvefjeld	240	69.27282	-53.45363
T3	Mast Skarvefjeld	399	69.27671	-53.45710
T2	Mast top of Skarvefjeld	833	69.28909	-53.43282
NV-hjørne	CALM plot Pjetursson	123	69.27313	-53.48222
NØ-hjørne	CALM plot Pjetursson	115	69.27343	-53.47998
SØ-hjørne	CALM plot Pjetursson	117	69.27262	-53.47906
SV-hjørne	CALM plot Pjetursson	118	69.27236	-53.48127
AWS1	Weather station Scientific leaders house	30	69.25328	-53.52003
AWS2	Weather Station Østerlien	25	69.25355	-53.51414
AWS3	Weather Station Blæsedalen	90	69.26553	-53.46732
AWS4	Weather Station Skarvefjeld	240	69.27282	-53.45363
EC-1	Eddymast Østerlien	25	69.25346	-53.51414
EC-2	Eddymast Blæsedal	85	69.26395	-53.47202
RE	Multisonde Røde Elv 436-2	5	69.25362	-53.49823
RE-1	Multisonde position 2013		69.25277	53.49917
RE-2	Multisonde position 2014		69.25684	53.49835
SW1	Soil water plot Østerlien		69.25349	-53.51363
AS	Photo site Arctic Station		69.25168	-53.51456
SS	Photo site Sorte Sand		69.25073	-53.51707
Block 1	Phenology plot SE-corner	85	69.26599	-53.46528
Block 2	Phenology plot SE-corner	84	69.26525	-53.46540
Block 3	Phenology plot SE-corner	85	69.26496	-53.46642
Block 4	Phenology plot SE-corner	86	69.26500	-53.46750
Block 5	Phenology plot SE-corner	86	69.26453	-53.46882
Block 6	Phenology plot SE-corner		69.26556	53.47050
Block 7	Phenology plot SE-corner		69.26469	-53.46231
Block 8	Phenology plot SE-corner	81	69.26529	-53.46228
Block 9	Phenology plot SE-corner	82	69.26551	-53.46310
Block 10	Phenology plot SE-corner	84	69.26677	-53.46305
Block 11	Phenology plot SE-corner	85	69.26673	-53.46432
Block 12	Phenology plot SE-corner	85	69.26674	-53.46490
	Red Hut Blæsedalen		69.26526	-53.47933
Cam_Østerlien	Camera Østerlien	30	69.25364	-53.51664
Cam_Lyngmark	Camera Lyngmark	385	69.27182	-53.54282
PRC	Precipitation totalizer Blæsedalen	90	69.26553	53.46732
Pheno 3 Camera	Phenology camera near Block 3	87	69.26495	53.46581
Pheno 4 Camera	Phenology camera near Block 4	88	69.26512	53.46662
Pheno 5 Camera	Phenology camera near Block 5	86	69.26461	53.46891
Pheno 8 Camera	Phenology camera near Block 8	88	69.26539	53.46227
Pheno 9 Camera	Phenology camera near Block 9	89	69.26556	53.46247
Pheno10 Camera	Phenology camera near Block 10	92	69.26684	53.46271
P1	Soil temperature Profile in Østerlien	25	-53.51401	69.25357
P2	Soil temperature Profile in Østerlien	25	-53.51417	69.25350