Guidelines and Sampling Procedures for the

Geographical Monitoring Program

GeoBasis Disko

Part of Greenland Ecosystem Monitoring (GEM)

Version - June 2018

Charlotte Sigsgaard

Department of Geosciences and Natural Resource Management (IGN)
University of Copenhagen

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 under construction/preliminary.
If you have questions or comments to this edition, please contact:

Charlotte Sigsgaard
Department of Geoscience and Natural Resource Management
University of Copenhagen
E-mail: cs@ign.ku.dk

Acknowledgement

Part of the GeoBasis Disko monitoring is based on the DiskoBasis-program (2013-2016) and GeoBasis also reflects a close collaboration with Arctic Station. This is the first version of the GeoBasis Disko Manual and besides the above tight connections it also uses guidelines and experiences given by the scientific consultants, field-staff, lab-staff and managers who have been involved in the GeoBasis monitoring in Zackenberg and Nuuk throughout the last 20 years. We would like to thank the following people: Bo Elberling, Aart Kroon, Ole Stecher, Christian Juncher Jørgensen, Casper T. Christiansen, Regin Rønn, Andreas Westergaard-Nielsen, Thor Nygaard Markussen, Morten Rasch, Anders Michelsen, Magnus Lund, Stine Højlund Petersen, Kirstine Skov, Birger Ulf Hansen, Mikkel Tamstorf, Anders Lambæk, Elisabeth Larsen Kolstad, Laura L. Frendrup, Jakob Abermann and Sille Myreng.

Thomas Friborg and Charlotte Sigsgaard

Front cover illustration:

The river Røde Elv. In the background the mountain Skarvefjeld (800 m). 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 intended to be 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 financed by Danish Ministry of Energy, Utilities and Climate.

A close collaboration and synergy with Arctic Station that is manned year round enables 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 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 focus on selected abiotic parameters in order 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 will be made freely available for research and education through the GEM database **http:/g-e-m.dk**. When using GeoBasis data the following acknowledgement must be included: Data from the Greenland Monitoring Program were provided by the department of Bioscience, Aarhus University, Denmark in collaboration with Department of Geosciences and Natural Resource Management, Copenhagen University, Denmark

Selected data and significant findings from each field season will be presented in GEM Annual Report Cards published by Aarhus University, DCE –Danish Centre for Environment. GeoBasis will also contribute to the "Arctic Station Annual Report" published by Faculty of Science, University of Copenhagen.

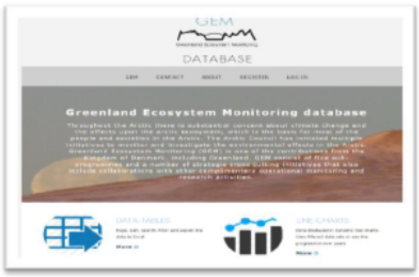
How to download data from GeoBasisDisko in the GEM database

- Data from Arctic Station can be downloaded from the GEM database (Greenland Ecosystem Monitoring) (http://g-e-m.dk)
- You have to register to log in and gain access to all data for free. See main menu REGISTER and LOG IN
- Read terms of use which can be found in the main menu ABOUT
- To enter the database –press either DATA-TABLES or LINE-CHARTS

If you need Air temperatures, please choose the following:
- **Program**: **GeoBasis Disko**
- **Program-group**: **Meteorology**
- **Group-Element: Automatic Weather Station 2 (AWS2) or (AWS1)**

- [Load data into data-table] or [Show Metadata]

Export data to Excel or CSV
- Fill in purpose (min 140 characters)



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). Arctic station was built in 1906 by M.P. Porsild. 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 is situated 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 pretty 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 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. The adjacent shores are aligned by wave processes 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.

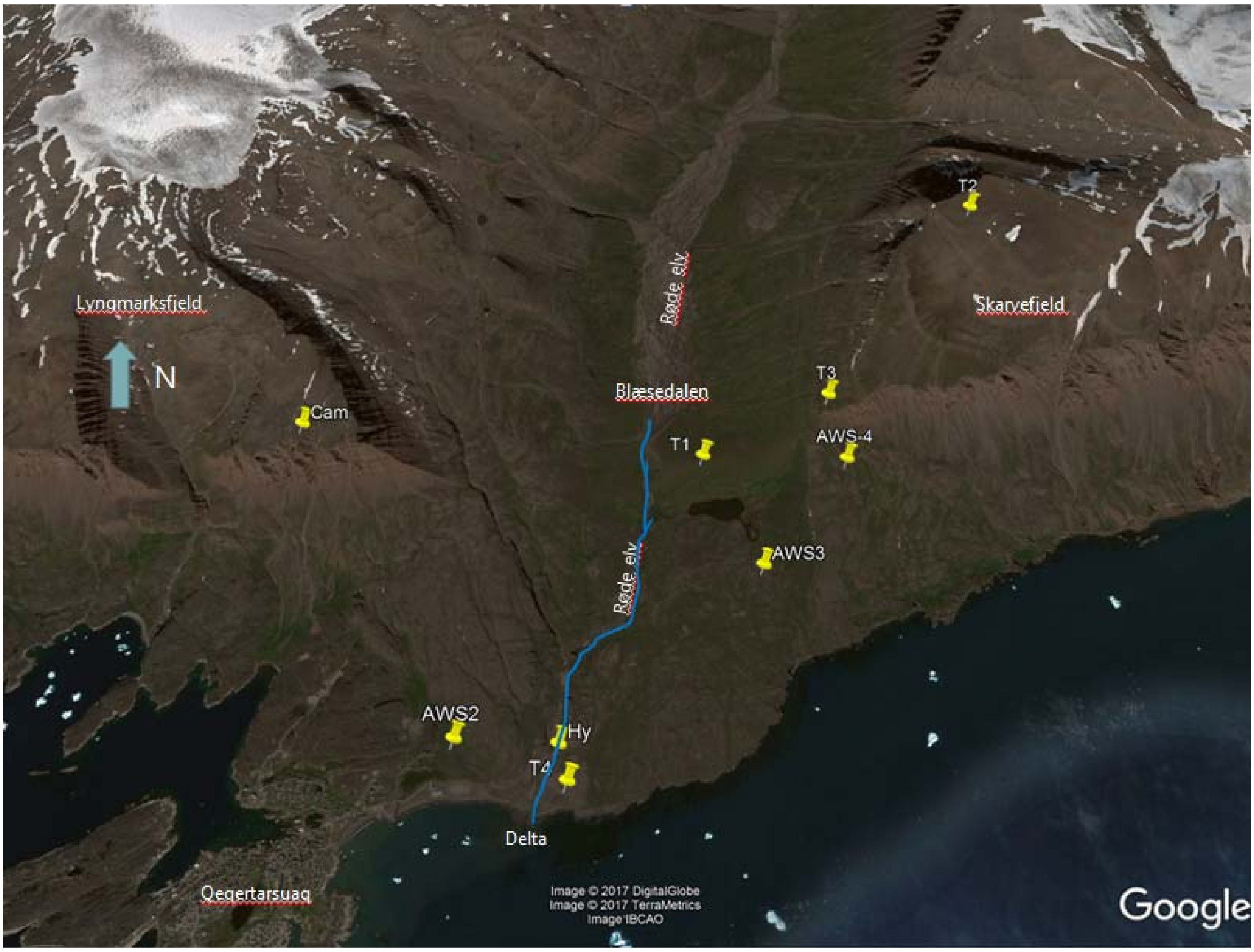


Figure 1.1 Location of main measuring sites for GeoBasis. Arctic Station is located near Automatic weather station (AWS) AWS2 in Østerlien. T1-T4 refer to temperature masts. Hy is the site for hydrological monitoring. The map background satellite image is copied from Google Earth and shows the very southern part of Disko island West Greenland. Image©2017 Digital Globe. This section is based on two images. The main part of the map is covered by an image provided by IBCAO , imagery date: 7/31/2015 and the very left part is covered by an image provided by Terrametrics, imagery date 7/22/2013.

Magnetic declination

Magnetic declination at Arctic Station 2018: -31°81’ W

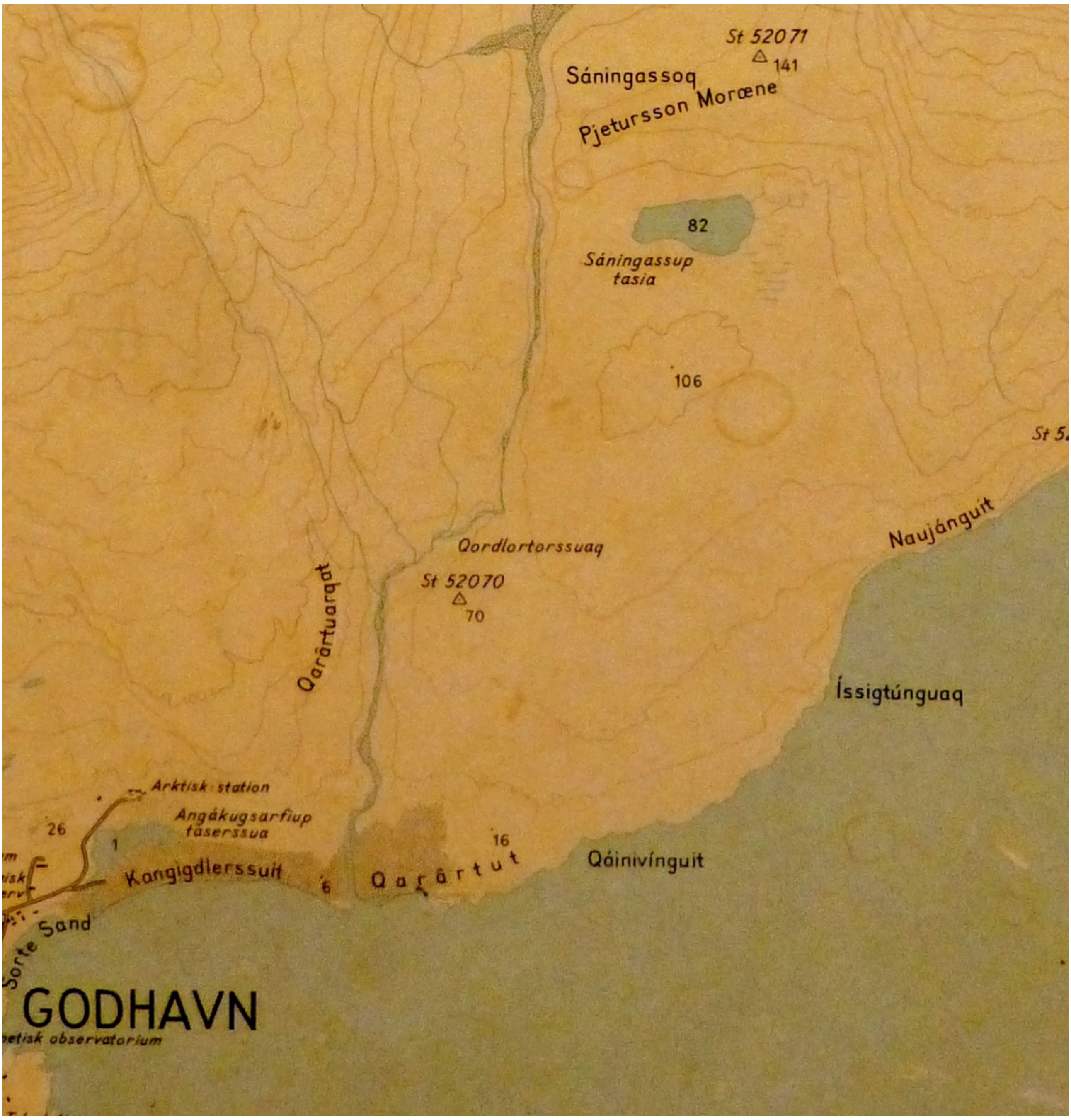


Figure 1.2. Map with indication of some elevation Fix points. Geodætisk Institut (1962)

1.4 GeoBasis Staff and Scientific consultants

GeoBasis manager

Thomas Friborg (Gas flux)
Department of Geosciences and Natural Ressource Management. University of Copenhagen
Øster Voldgade 10, 1350 København K, Denmark

Field assistant and data manager

Charlotte Sigsgaard
Department of Geosciences and Natural Ressource Management, University of Copenhagen
Øster Voldgade 10, 1350 København K, Denmark

Scientific consultants

Andreas Westergaard-Nielsen (Photo monitoring)
Department of Geosciences and Natural Ressource Management, University of Copenhagen
Øster Voldgade 10, 1350 København K, Denmark

Birger Ulf Hansen (Climatology)
Department of Geosciences and Natural Ressource Management, University of Copenhagen
Øster Voldgade 10, 1350 København K, Denmark

Bo Elberling (Soil and Chemistry)
Department of Geosciences and Natural Ressource Management, University of Copenhagen
Øster Voldgade 10, 1350 København K, Denmark

Thomas Friborg (Gas flux)
Department of Geosciences and Natural Ressource Management. University of Copenhagen
Øster Voldgade 10, 1350 København K, Denmark

Staff at Arctic Station

Morten Rasch
Scientific leader Arctic Station
Arctic Station
3953 Qeqertarsuaq, Greenland

Kjeld Akaaraq Mølgaard
Station manager
Arctic Station
3953 Qeqertarsuaq, Greenland

1.5.GeoBasis Disko Field notes (daily report)

During the field season the following must be recorded in a GeoBasis daily journal:

- Weather report (temperature, clouds, precipitation, wind, fog)
- Details about work carried out every day
- Condition of the river Røde Elv (sediment, color/visibility, level, snow/ice drift)
- Snow and ice situation (cover, distribution, presence)
- Ideas and thoughts of improvement to the program and procedures

2 Automatic Weather Stations

2.1 Introduction

Monitoring of essential meteorological variables across various surface types and elevations are part of GeoBasis. At Arctic Station meteorological parameters has been recorded since 1991 where an automatic weather station was established next to the scientific leader's house. Data from this station called AWS1 are now made available in the GEM database. Data collection from this station ends in the summer 2017. In August 2012, a new automatic weather station (AWS2) was installed in Østerlien just east of Arctic Station. More weather stations have been included within the last years; AWS3 in 2013, T1-T4 in 2014, and AWS4 in 2015 (Figure 2.1). Together they represent an altitudinal gradient from sea level to 800 m amsl. At all stations air temperature is measured but apart from that the stations are not equally equipped. AWS2 is the most extensive of the stations with most parameters being logged whereas T1-T4 only records air and ground surface temperature. All these stations are part of the GeoBasis program.

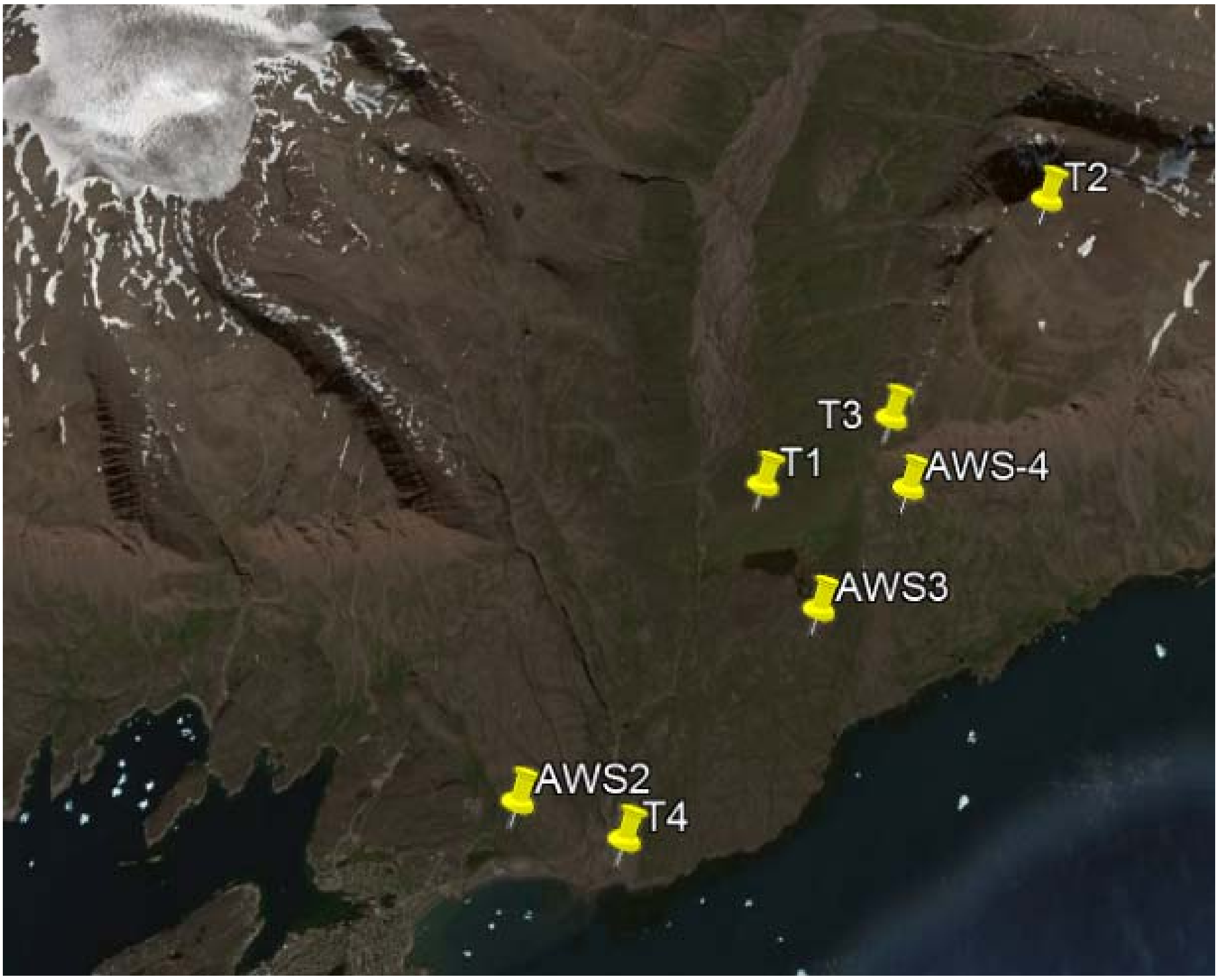


Figure 2.1. GeoBasis automatic weather stations in the landscape around Arctic Station. The stations cover an altitudinal gradient from sea level (T4) to 800 m asl (T2).

A brief summary of the air temperature from 1992 to 2016 are given in Figure 2.2. Annual means has been increasing, especially in the nineties and primarily in the winter. The annual mean is close to zero. Mean monthly temperatures vary a lot during winter and less during summer. February and March are the coldest months and July the warmest month. Maximum air temperatures during summer was 21.9 °C and lowest temperature during winter was 32.9°C (recorded at AWS1 from 1991-2016).

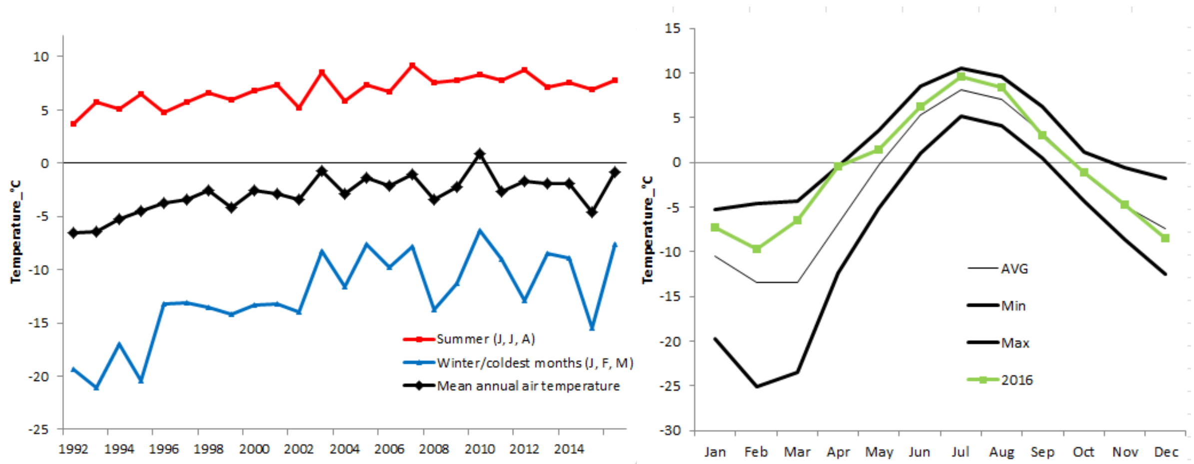
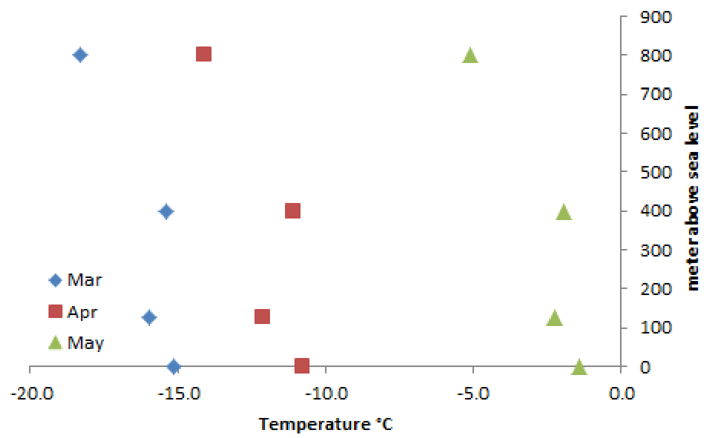


Figure 2.2 Annual mean air temperatures at Arctic Station from 1992 to 2016 and mean air temperatures for the warmest months (June, July and August) and the coldest months (January, February and March).

Temperature inversions

Temperature inversion, a reversal of the normal behavior of temperature in the troposphere (the region of the atmosphere nearest the Earth's surface), in which a layer of cool air at the surface is overlain by a layer of warmer air. Under normal conditions air temperature usually decreases with height. As part of GeoBasis we have temperature masts placed at various elevations to study the altitudinal gradient. In the figure below, monthly air temperatures are shown for March, April and May. These months are examples of months where you find higher temperatures at 400 than at 125 meter which means there is an inversion of the expected lapse rate. See more in section 2.5 temperature masts T1-T4.



Where to find data in the GEM Database

Program: GeoBasisDisko, **Program group**: Meteorology, **Group-element**: AWS1, AWS2, AWS3, AWS4, T1, T2, T3, T4.

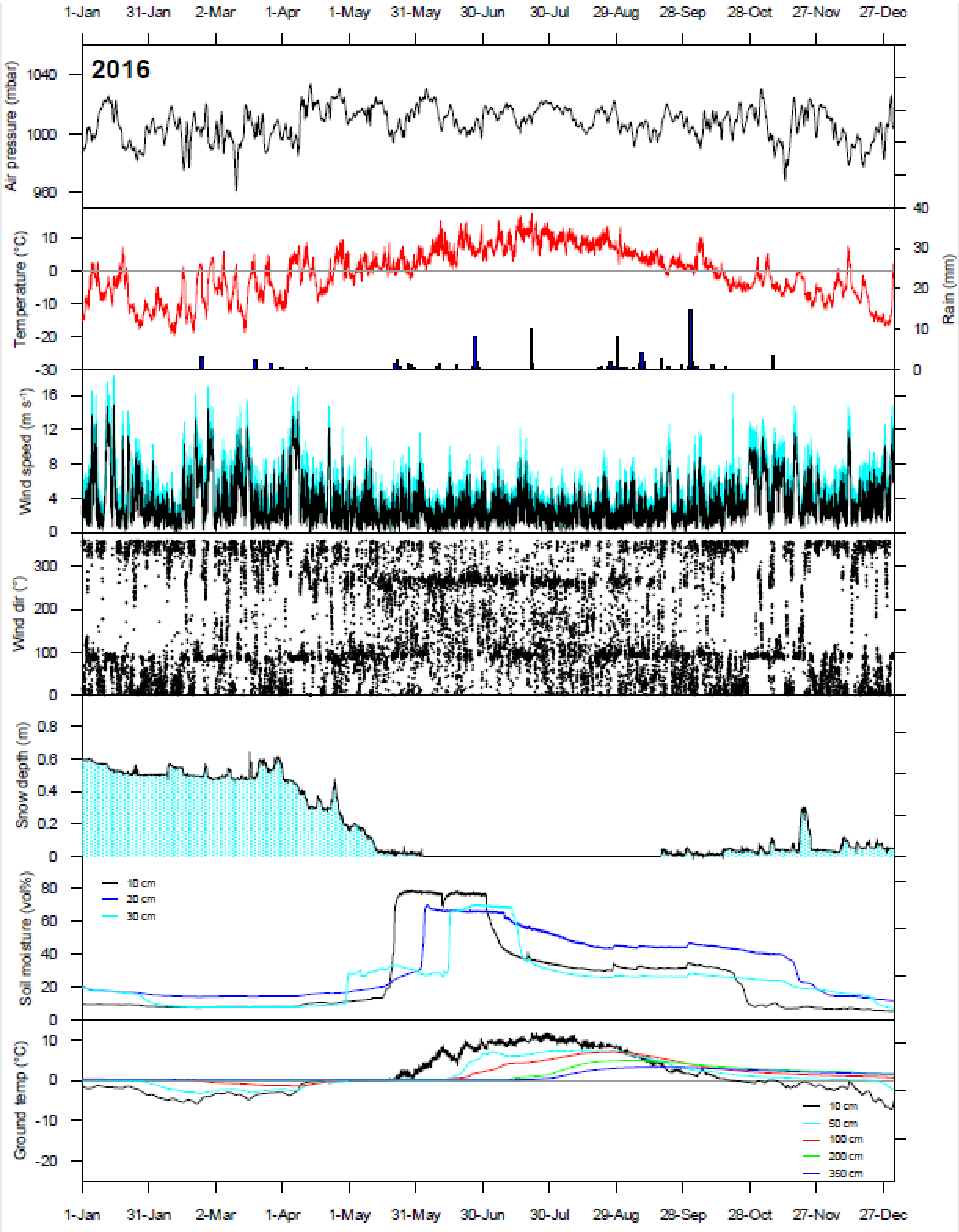


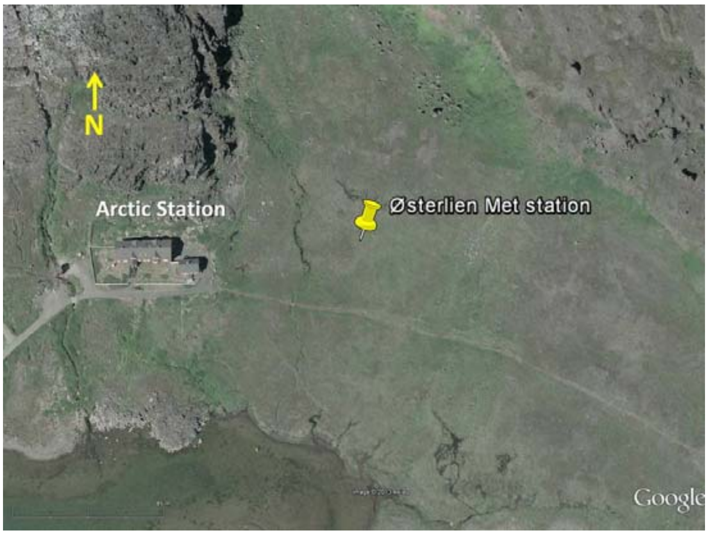
Figure 2.3. Temporal variations of selected parameters from the automatic weather station (AWS-2) in Østerlien in 2016 (data logged every 30 min). Air Pressure, air temperature, precipitation (rain measured at AWS-1), wind speed (mean and max), wind direction, snow depth, soil moisture and ground temperatures from 10, 50, 100, 200 and 350 cm.

2.2 Automatic Weather Station AWS-2 Østerlien

The station consists of two masts; one where common/general meteorological and energy balance parameters are measured, and one where micrometeorological/gas flux parameters are being measured by use of eddy covariance technique (Figure 2.4). Finally, there is a separate metal stick/pole where soil temperatures and air/snow temperatures are measured. A list of all sensors and measured parameters are given in Appendix 1.

AWS-2 Østerlien

Located 100 m west of the garage at Arctic Station in a gentle south sloping area covered by low vegetation/dwarf shrubs.
Position: 69°15'12.558'' N, 53°30'50.863''W
Elevation: 25 m a.s.l. (Google Earth)
Operation: 2012-
Instrumentation of the mast: see Appendix 1
Power: cable from AS, solar panel
Datalogger and download: CR1000 and cable transmission
Time log: Greenlandic Wintertime (UTM-3)
Logging interval: 30 min



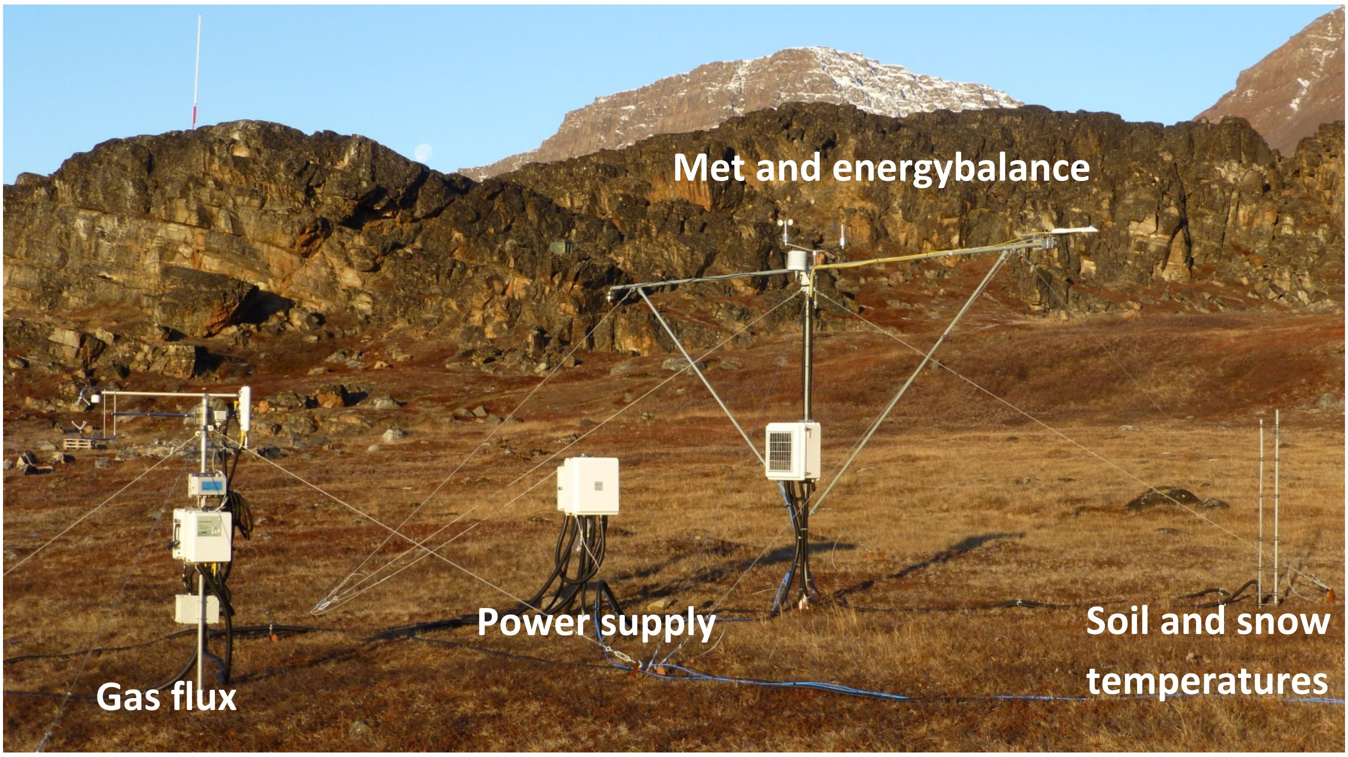


Figure 2.4 The Automatic Weather Station AWS2 in Østerlien.

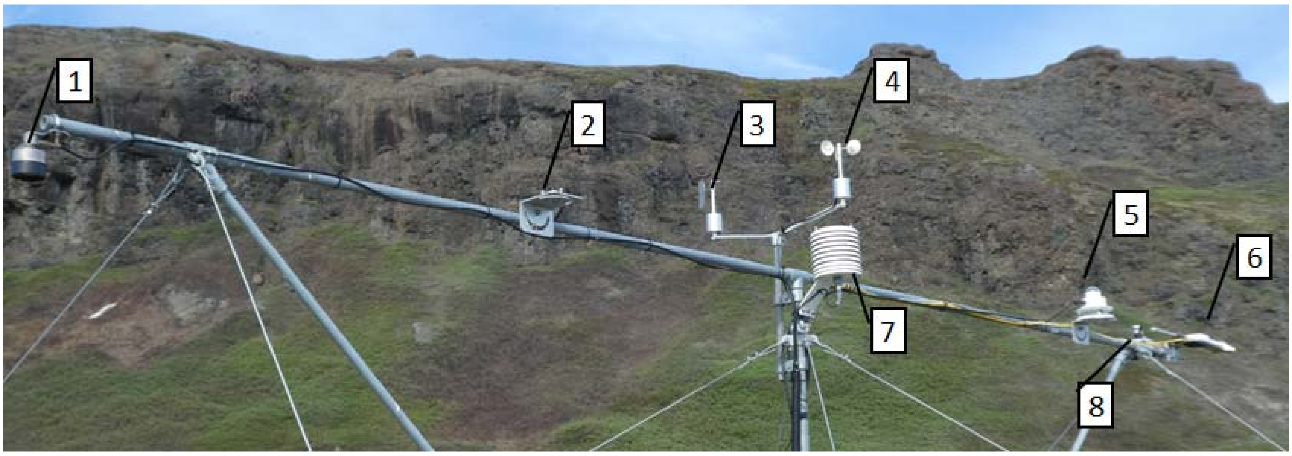


Figure 2.5 The Automatic Weather Station AWS2 in Østerlien. 1) Snow depth (SR50 Sonic sensor), 2)PAR sensor, 3)Wind direction, 4) Wind speed, 5) UVB sensor, 6) Net radiometer CNR4, 7) Temperature and humidity sensor, 8) SKYE sensor RED/NIR

The meteorological mast of the weather station is built on a 3 m long steel rod with a long cross beam pointing more or less east-west. In the eastern end of the cross beam the radiation sensors (CNR4) are mounted. In the other end, pointing toward west, the snow depth sensor (SR50A) is mounted. Wind speed and wind direction, air temperature and humidity sensors are placed at the center 3 m above ground (Figure 2.5). The eddy covariance mast is equipped with a 3D sonic anemometer (Gill-HS) placed 2 m above terrain and a Licor-7200 gas analyzer. The air-inlet is placed inside the white cup right above the center of the anemometer. A white enclosure holds the Licor-7550 Analyzer Interface Unit and another white enlosure houses the Licor-7200 Flow module (figure 2.6). Above the enclosures a Gill interface unit is mounted.

2.2.1 Offloading data from AWS-2 Østerlien

Data is continuously logged and transmitted to a computer in the garage at Arctic Station (Figure 2.6). From this computer data is uploaded to a Dropbox. On the computer screen you can see live update from the Licor-7200 and check that values look reasonable –change settings and so on. It is also from this computer you can communicate with the Campbell CR1000 datalogger e.g. send a receive programs from the datalogger and see live updates via the Campbell software Loggernet.

Frequency

Data from the Licor-7200 must be offloaded once a week (half hourly files of 6 MB takes up a lot of space in the Dropbox) and data from the Campbell logger must be offloaded once a month. The main reason for these download intervals are to be able to check the data on a regularly basis. More data can be stored without problems. If the Dropbox is full, files will be saved on the computer and files will be transmitted when free space is regained.

Figure 2.6 Location of the computer in the AS Garage 1st floor. Data from AWS2 in Østerlien are transmitted to the computer inside the wooden box. <u>Access to this computer is only for GeoBasis staff.</u>

Procedure for offloading via Dropbox

1. You need an invitation to the Dropbox account to access the data from a remote location (Contact: Mathias Madsen, IGN)

2. Data from AWS2 are located in the folder “Scheduled collection”: (Local Disk C:/Dropbox/AS Disko Oesterlien/Scheduled collection). There are two datalogger files; CR1000MetData.dat (contains meteorological parameters) and CR1000MUX2.dat (contains all soil temperature data).

3. Copy the two datalogger files; CR1000MetData.dat and CR1000MUX2.dat to the folder I:\SCIENCE-CENPERM-DATA01\Arctic Station\AWS-2\Original data\YYYY\YYYY.MM.DD

4. Data from the Eddy covariance mast are stored as half hourly files in the folder “Licor” (Local Disk C:/Dropbox/AS Disko Oesterlien/Scheduled collection/Licor) and can be copied from there to the folder I:\SCIENCE-CENPERM-DATA01\Arctic Station\CO2 flux mast\YYYY.

5. As soon as the Licor data are copied to the backup drive they must be deleted from the Dropbox

Procedure for offloading data from the local computer

1. Bring an USB external harddisk to the garage and connect it to the computer inside the wooden box (Figure 2.6)

2. Data from AWS2 are located in the folder “Scheduled collection”: (Local Disk C:/Dropbox/AS Disko Oesterlien/Scheduled collection).

3. There are two datalogger files; CR1000MetData.dat (contains meteorological parameters) and CR1000MUX2.dat (contains all soil temperature data).

4. Copy the two datalogger files; CR1000MetData.dat and CR1000MUX2.dat to the harddisk

5. Data from the Eddy covariance mast are stored as half hourly files in the folder "Licor" (Local Disk C:/Dropbox/AS Disko Oesterlien/Scheduled collection/Licor) and can be copied from there to the harddisk

6. Always copy the data files when you offload directly from the computer. Only delete/cut data if agreed with data manager (Contact: Charlotte Sigsgaard)

Quick validation of data

To verify that sensors are (and have been) working satisfactory, prepare a worksheet with a copy of data and create charts of every parameter.

- Check that the time series is OK. Insert a column of correct times and compare with the actual time column. Check that the first and the last data point agree with times of data removal from the logger
- Original files from the Eddy covariance mast (EC1) can be viewed 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

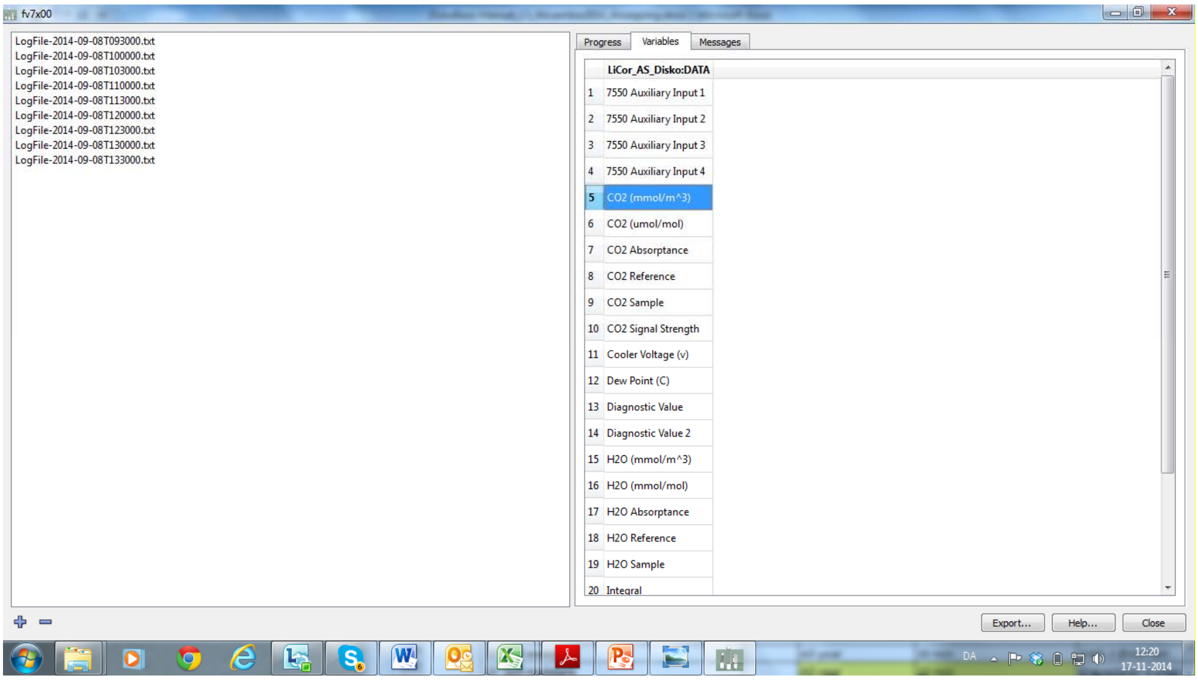


Figure 2.7. Screen from the Li7x00 File Viewer software

- Check that seasonal variation in parameters looks reasonable. If anything looks suspicious or if a sensor has failures or major dropouts, please report to Charlotte Sigsgaard (cs@ign.ku.dk)

2.2.2 Live update from the AWS-2 in Østerlien

In the Arctic Station main building there is a screen/monitor showing live-update of some relevant parameters from the Automatic Weather Station (AWS2) in Østerlien; air temperature, air pressure, wind speed, wind direction and soil temperatures (Figure 2.8). Once in a while the window freeze or the update stops working properly. Most problems can be solved by a computer restart (see below). The computer is just a small black box located behind the monitor. Changes to the set-up can be applied via Loggernet software.

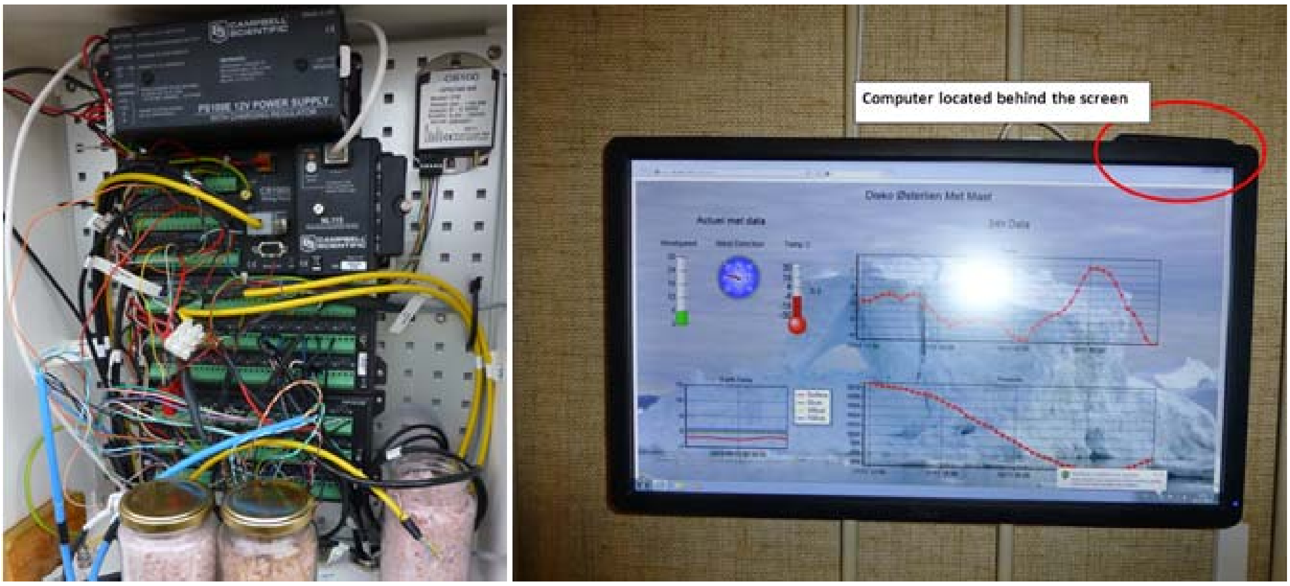


Figure 2.8. The CR1000 datalogger at the AWS2 mast (left). Monitor with live update (real time) from AWS2 located inside Arctic Station.

Procedure

1. Close down the computer and restart. There is no password and the program starts/load automatically. If no mouse or keyboard is present you can also do it in a more brutal way by pressing the Power bottom on the black box for some seconds until it closes down –and then just press power to start up again after 20 seconds.

2.3 Automatic Weather Station AWS-3 Blæsedalen

In July 2013, an automatic weather station (AWS3) was installed in Blæsedalen within the CENPERM experimental site. The station consist of a tripod mast (2 m) with a cross beam. A precipitation bucket is placed separately on a lower mast just north of the tripod. In 2016, a precipitation collector was mounted 25 meter 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 relative dry area where the bedrock is only covered by thin layer of soil covered with low heath vegetation/dwarf shrubs
Position: 69°15' 930'' N, 53° 28' 015'' W
Elevation: 90 m asl
Operation: 2013-
Instrumentation of the mast: see Appendix 1
Power: Solar panel and battery
Datalogger and download: CR1000
Time log: Greenlandic Wintertime (UTM-3)
Logging interval: 30 min

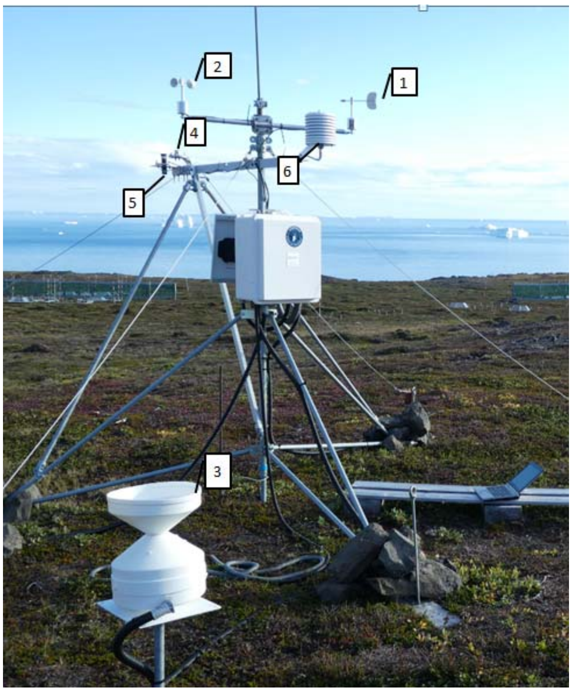


Figure 2.10 AWS3 Blæsedalen. 1) Wind direction, 2) Wind speed, 3) rain, 4)PAR, 5) NDVI, 6) Air temperature and relative humidity

2.3.1 Offloading data from AWS3 Blæsedalen

Data is offloaded from the CR1000 datalogger via direct cable connection.

Frequency

Data from AWS3 must be offloaded at least twice a year. When the field season starts in May/June and again when the field season ends in September/October.

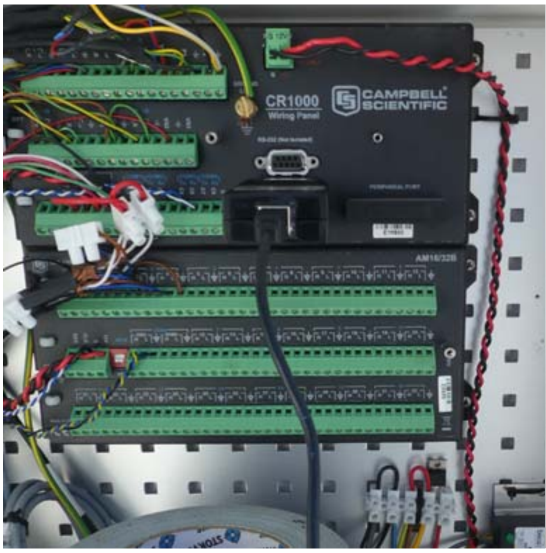
What to bring

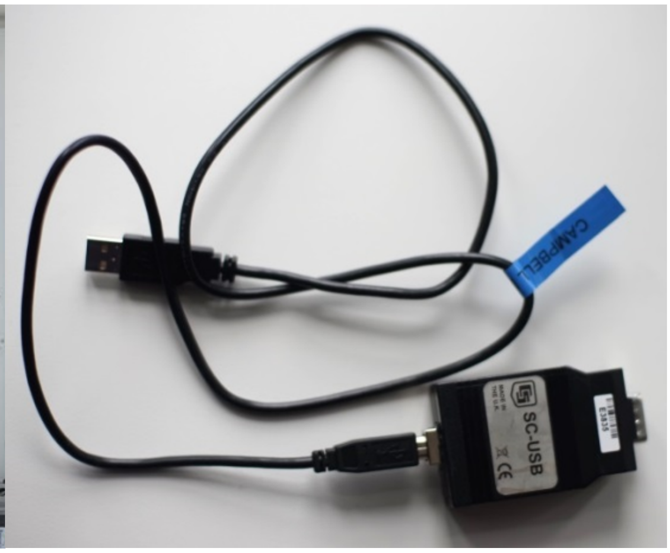
- Laptop with Campbell software Loggernet installed
- Communication cable from Campbell (USB to serial) SC –USB
- Camera
- Voltmeter
- Silica bags

Procedure

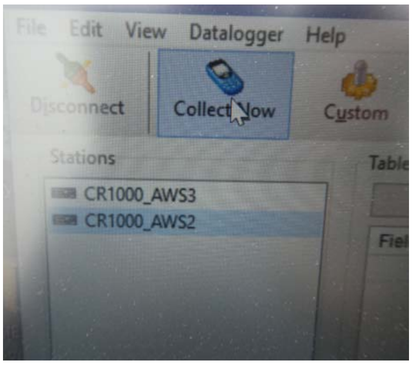
1. Enter the station via the boardwalk and open the white enclosure

2. Attach the cable to the CS I/O port on the datalogger and to the USB port on the computer (see photo below)





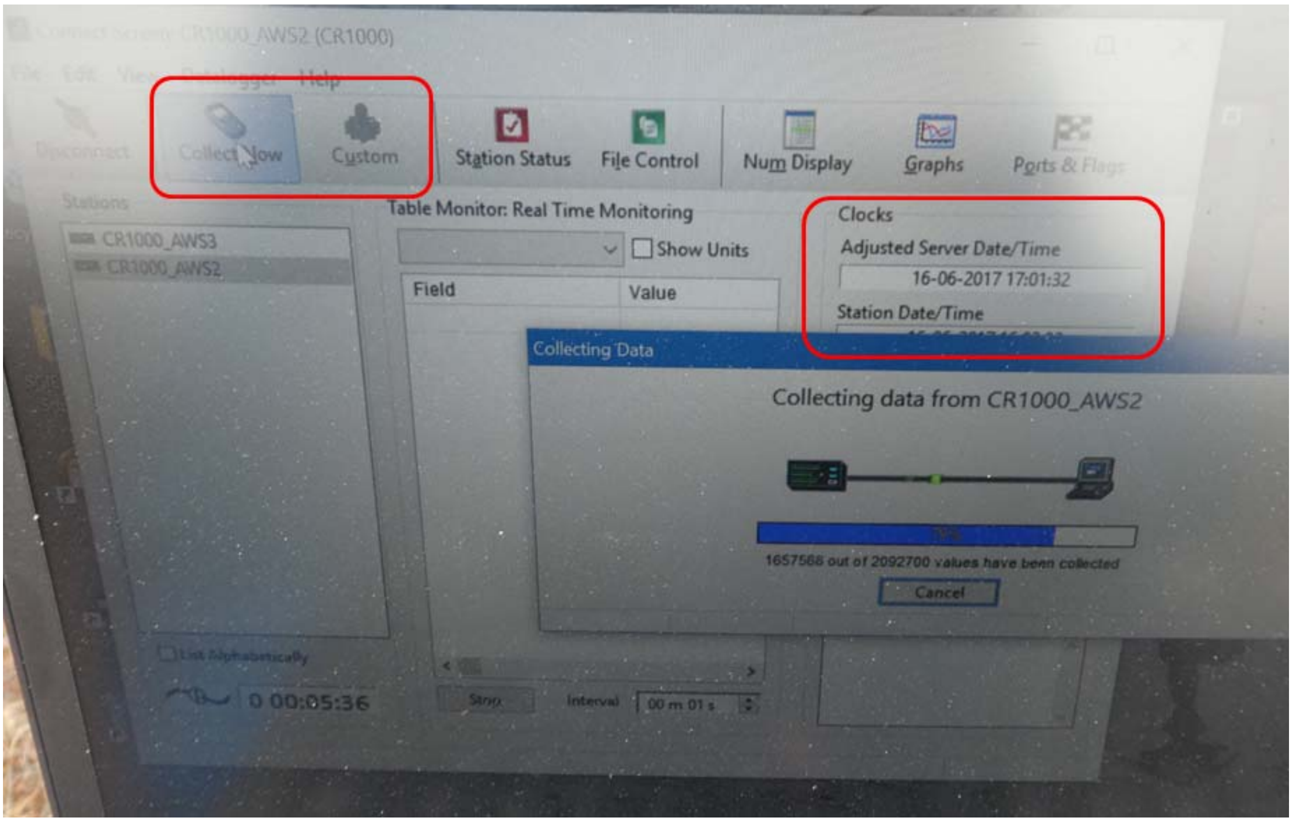
3. From the main menu in Loggernet select [Connect]



4. Select the station CR1000_AWS3ny from the station list and press [Connect]

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

6. 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).



7. Data will be 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

8. Check and note the Adjusted server Date/Time + Station Date/Time on the screen (main menu –see above screen photo). AWS-3 is running Greenlandic winter time (UTM-3)

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

10. 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. Select [Setup] from the Loggernet main menu and [Add] a new datalogger… (see the slide below)

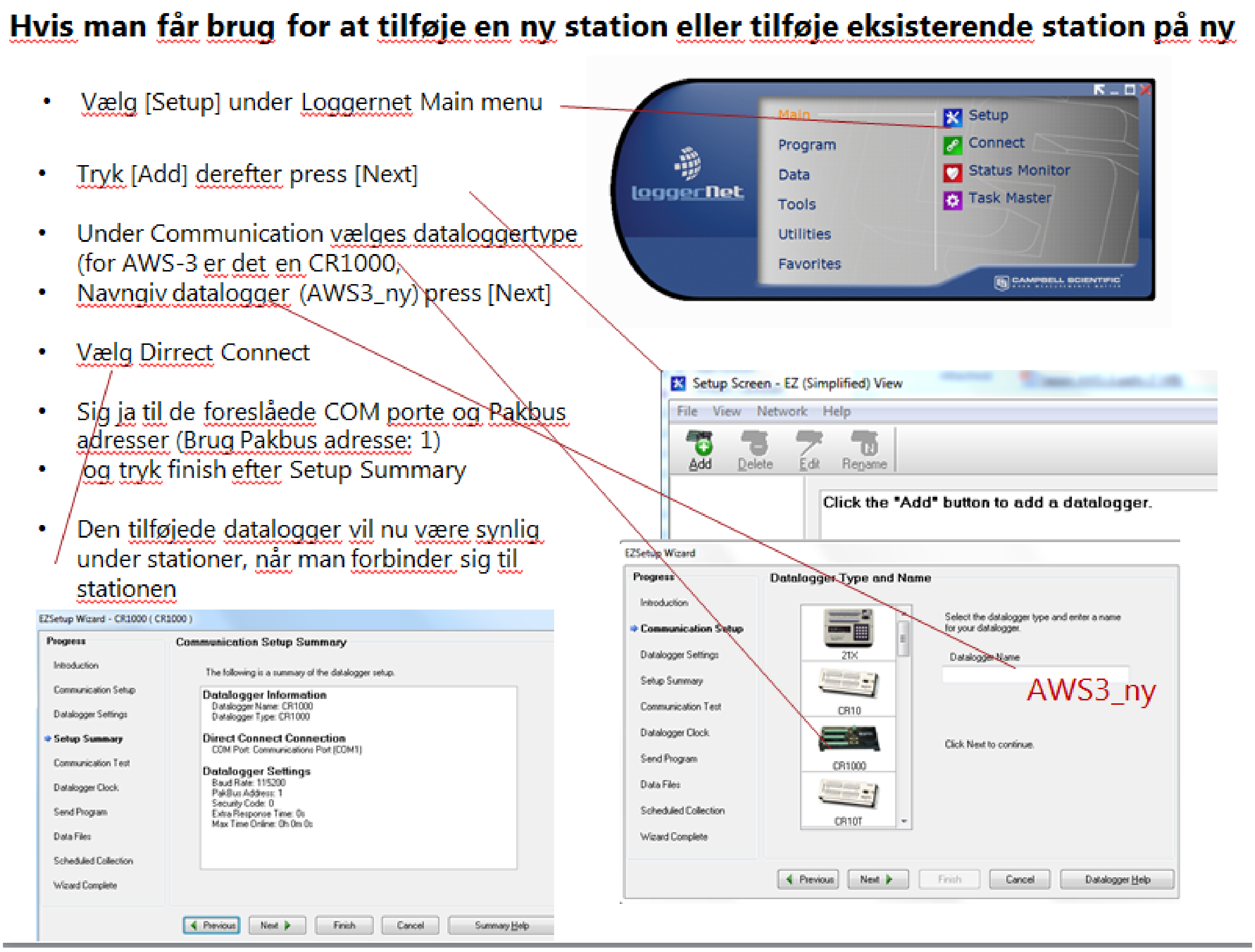


Figure 2.11. Slide showing how to add a new station in Loggernet.

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.
- 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 Datamanager.

2.4 Automatic Weather Station AWS-4 Skarvefjeld

The automatic weather station AWS4 is located 240 m asl on the southern slope of Skarvefjeld next to an experimental CENPERM site (Figure 1.1 and 2.12).

AWS-4 Skarvefjeld

Located 240 m above sea level on the southern slope of Skarvefjeld.
Position: Dec degrees: N 69,27282° W 053,45363°
Elevation: 240 m asl
Operation: 2015-
Instrumentation of the mast: see Appendix 1
Power: Solar panel
Datalogger and download: HOBO U30 station from Onset
Time stamp: Greenlandic Summertime (UTM-2)
Logging interval: 30 min

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

2.4.1 Offloading data from AWS-4 Skarvefjeld

Frequency

Data from AWS-4 must be offloaded 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

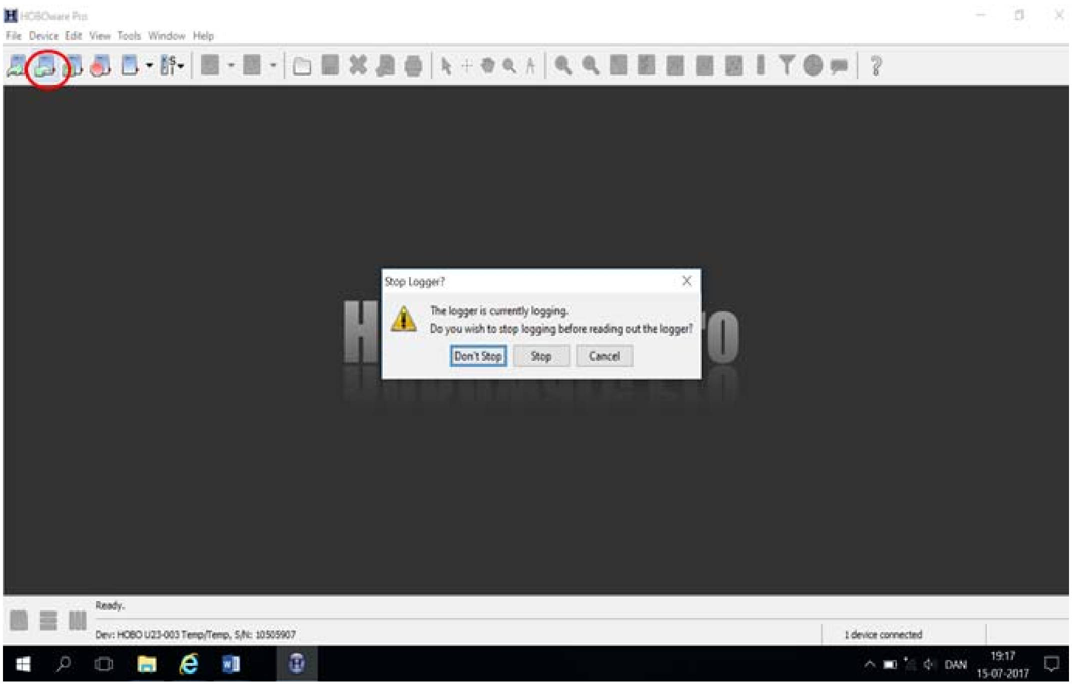
- Laptop with HOBOware Pro installed
- Camera
- Voltmeter
- Silica bags
- GeoBasis manual and HOBO U30 station User guide (GeoBasis/Manuals/HOBO U30)
- Scotch 33+ tape
- Small screw driver or multitool

Procedure

1. Inside the enclosure on the mast there is a box with the HOBO datalogger. Inside this box the communication cable is stored and left (Remember to leave it there). Connect the cable to the slot marked with a circle (Fig 2.13) and the USB part of the cable to the laptop. Start HOBO Pro software

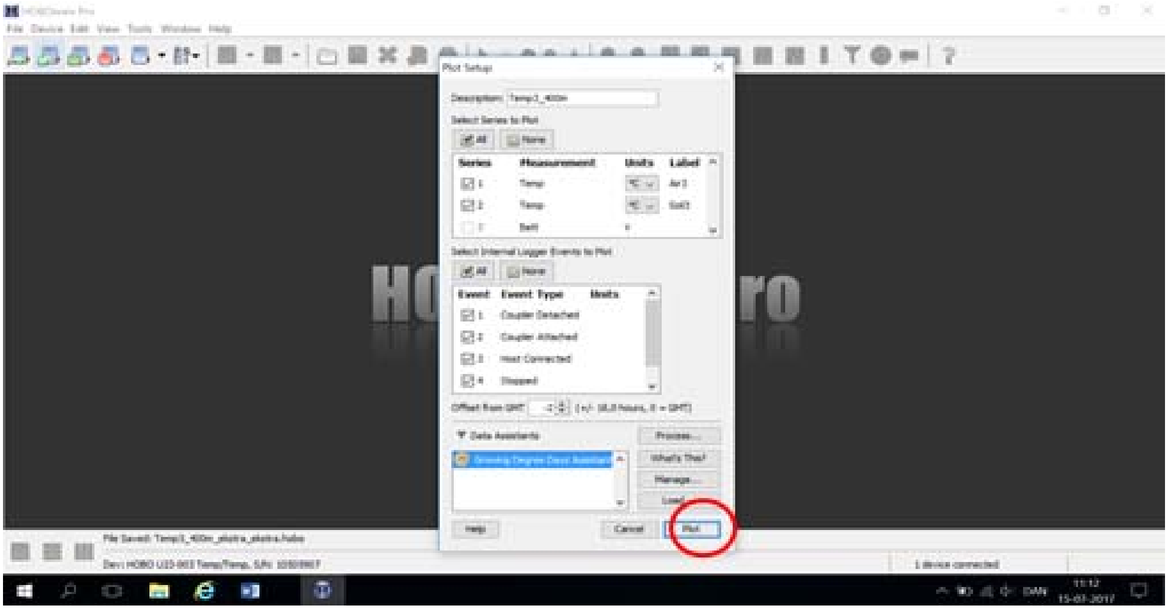
Figure 2.13 Inside the enclosure is the HOBO U30 box. The red circle mark the communication slot

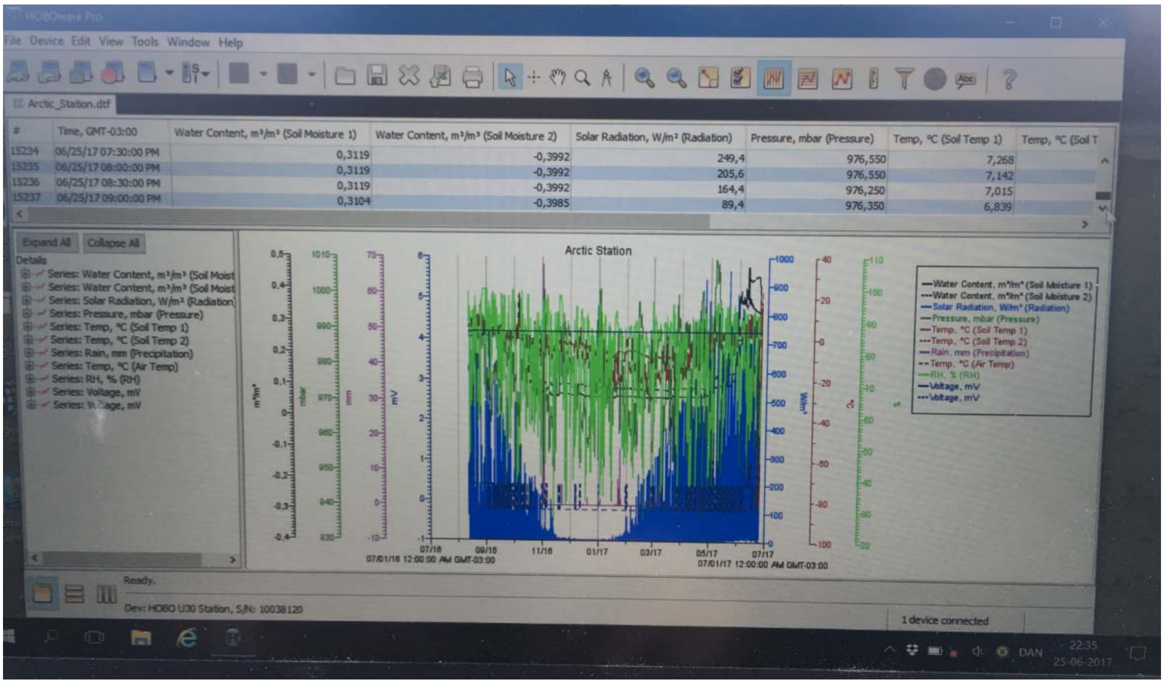
2. When you are connected to the station. Press [Read out device] in the main menu (marked with a red circle). Data can be offloaded without stopping the logger. But at least once a year the logger must be stopped and re-launched in order to clear the memory and gain free space for data storage. (<u>Note: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



3. Select where to save offloaded data and press [Save]. The offloaded data file is now saved.¨

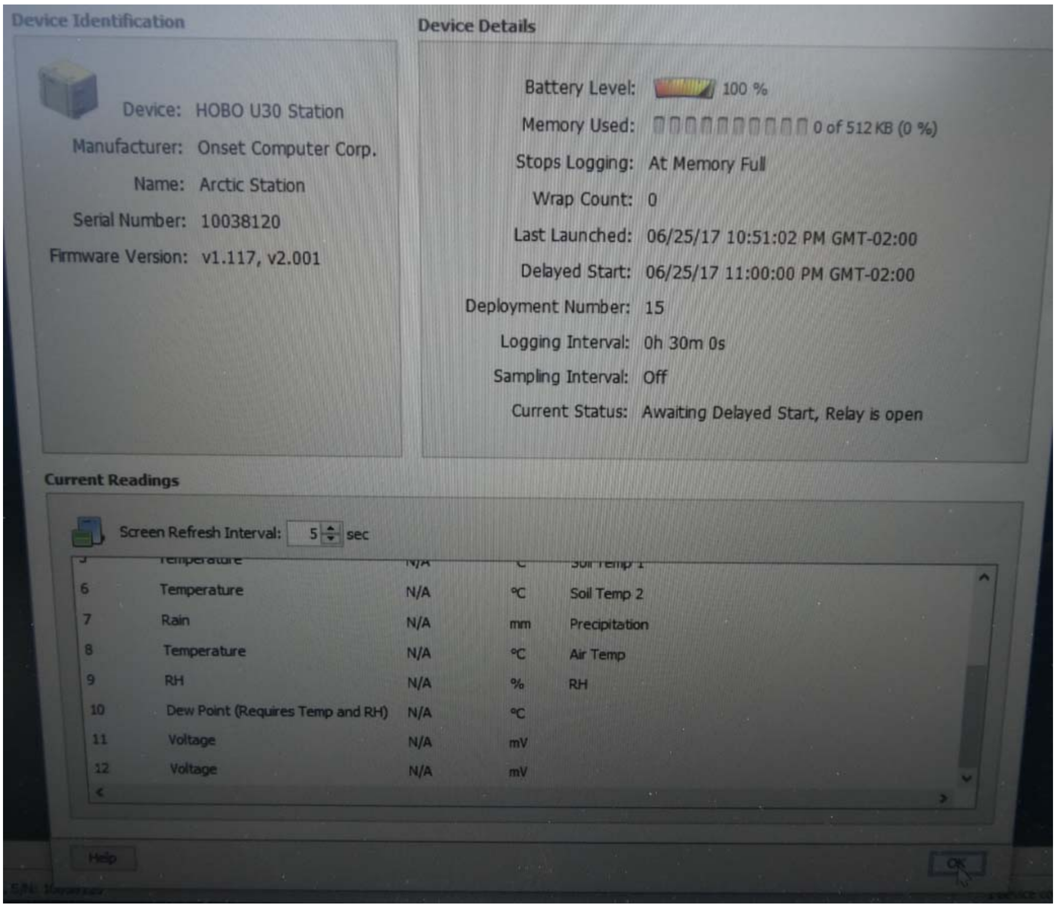
4. In the window Plot setup press [Plot] in the lower right corner to see the data plotted





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

6. Select the icon [Device Status] from the main menu to see actual readings and to check memory and current status of the logger. Take a photo or make a screen dump. If the memory has to be cleared you must stop and Re-launch the logger



2.4.2 Re-launch HOBO logger AWS4 Skarvefjeld

1. To launch the station select [Launch Device]. Go through all settings and make sure they are correct. The station run Greenlandic summertime (UTM-2). 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 date and time for start of logging (next hour: HH:00)

2. After re-launch of the station. Check 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/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 to take into account what time the datalogger runs)

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 timesteps). 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.

2.4.2 Troubleshooting

If you cannot connect to the logger:

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

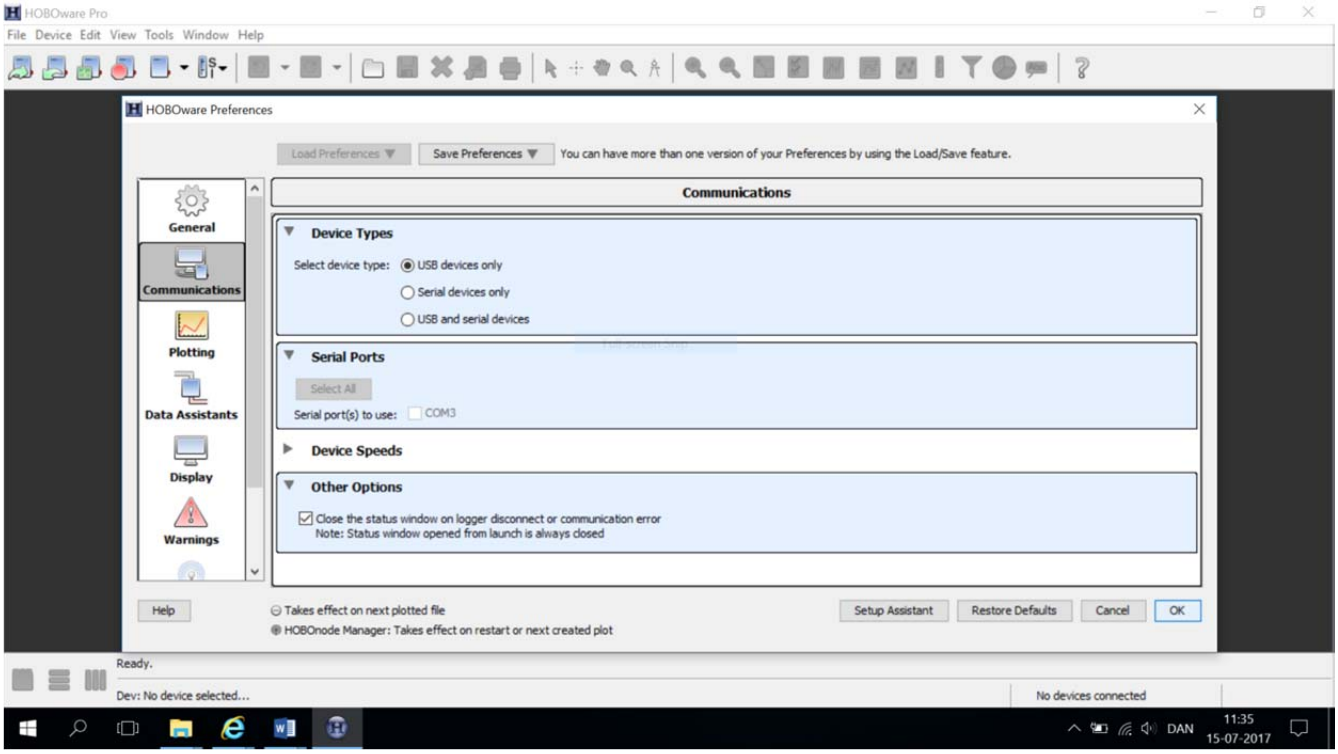


Figure 2.14 HOBOware Preferences. Check device types

2.5 Temperature mast T1-T4

The masts T1, T2, T3 and T4 are very basic stations. 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 meter above terrain and another one at the ground surface. They were installed in order to study an altitudinal temperature gradient from sea level to the top of Skarvefjeld.

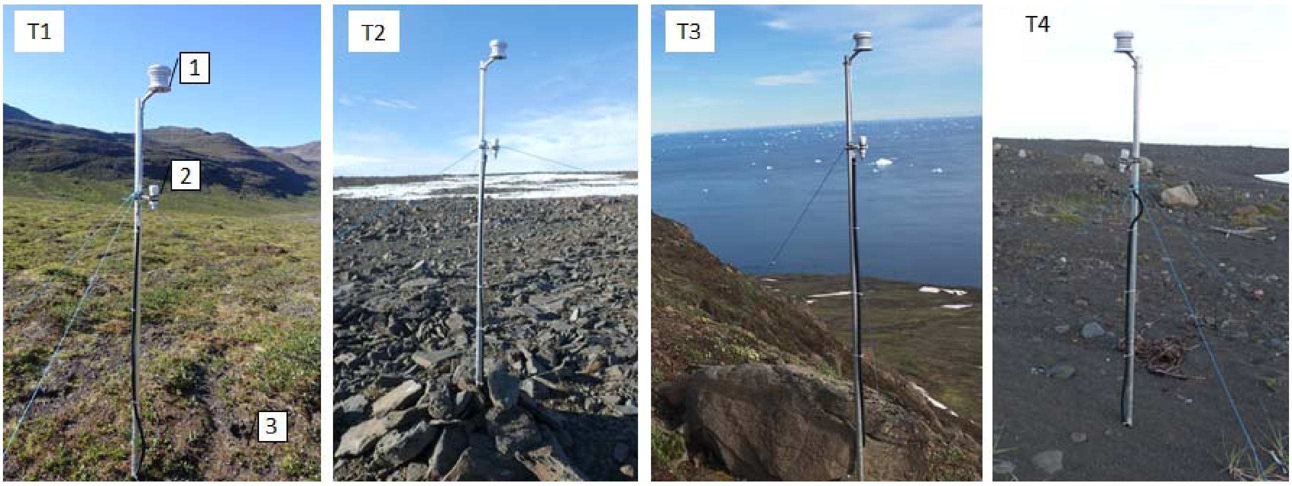


Figure 2.15: T1: Pjeturssons moraine ridge (125 m), T2: Top of Skarvefjeld (830 m), T3: Skarvefjeld ridge (400 m), T4: Røde Elv delta (1 m). 1 Air temperature, 2 datalogger, 3 ground surface temperature

T1

T1 is located on the top of Pjeturssons moraine ridge. It is a flat open vegetation covered area.
Position: 22W, 7686787mN, 402094mW
Elevation: 125 masl
Operation: 2014-
Instrumentation of the mast: -Appendix 1
Power: Battery
Datalogger and download: HOBO U23-003
Time stamp: Greenlandic Summertime (UTM-2)
Logging interval: 30 min

T2

T2 is located on the top of Skarvefjeld in the western end of the mountain plateau. It is placed in a flat rocky non vegetated open area.
Position: 22W, 7688506mN, 404002mW
Elevation: 830 masl
Operation: 2014-
Instrumentation of the mast: -Appendix 1
Power: Battery
Datalogger and download: HOBO U23-003
Time stamp: Greenlandic Summertime (UTM-2)
Logging interval: 30 min

T3

T3 is located on the slope of Skarvefjeld along the southwestern ridge.
Position: 22W, 7687165mN, 402989mW
Elevation: 400 masl
Operation: 2014-
Instrumentation of the mast: -Appendix 1
Power: Battery
Datalogger and download: HOBO U23-003
Time stamp: Greenlandic Summertime (UTM-2)

Logging interval: 30 min

T4

T4 is located on the eastern side of the Røde Elv River delta
near the coast. It is placed in dark sandy/gravel material
Position: 22W, 7684396 mN, 401220 mW
Elevation: 1 masl
Operation: 2014-
Instrumentation of the mast: -Appendix 1
Power: Battery
Datalogger and download: HOBO U23-003
Time stamp: Greenlandic Summertime (UTM-2)
Logging interval: 30 min

2.5.1 Offloading data from T1-T4 (HOBO U23-003)

What to bring

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

Procedure

1. Remove the white UV protection cap from the HOBO logger and place the USB Base Station on top (see figure)

2. Connect the USB end of the cable to the laptop and start HOBOware Pro

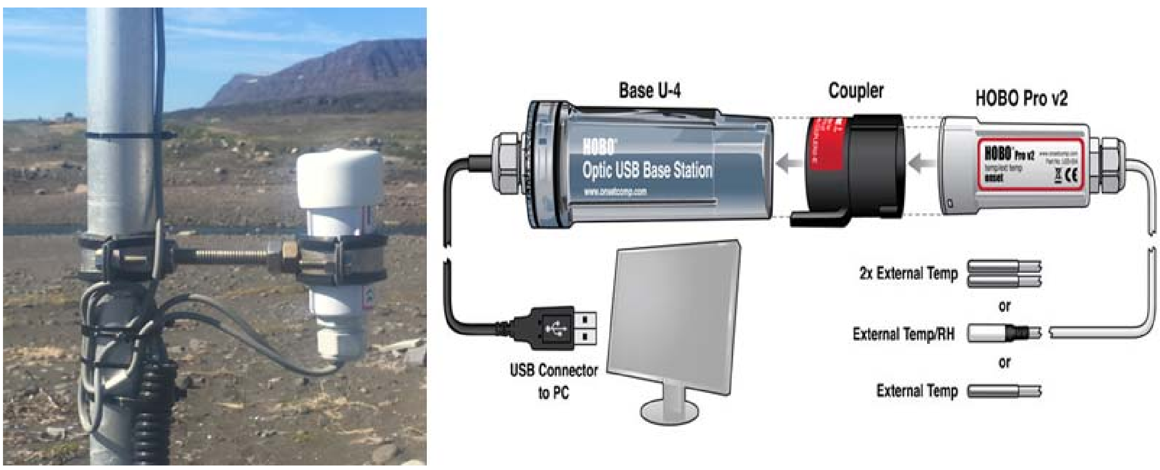


Figure 2.16. HOBO mast T4 in the delta. Looking towards west. Datalogger with protection cap that must be removed when communicating with the logger.

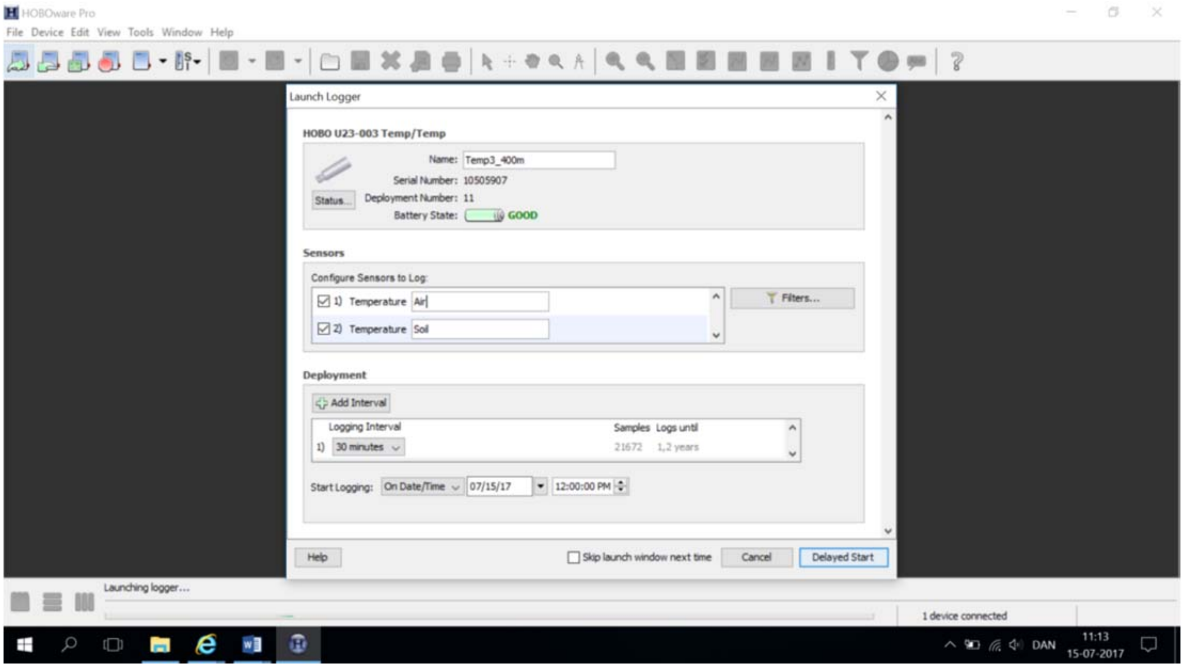
3. Follow the procedure given in section 2.4.1: Offload data from AWS4 Skarvefjeld

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

5. 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-T4

Follow the procedure given in section 2.4.2 . For HOBO-U23 the launch window looks like this:



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 (Remember to consider what time the datalogger runs)

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 timesteps). 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 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 log. Each station has a log –either a book inside the box or at least in the Excel Worksheet where you check the data. Remember to write down date and exact time (specify Time Greenlandic summer or winter).

Date	Time (UTM-2)	Information	Person
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. The raincollector cable are chewed and broken	C. Sigsgaard

What to bring

- Silica bags
- Tissue
- Tommestok, folding rule
- Tape + strips
- Bubble level
- Soft clean clothing
- Volt meter
- 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 libelle vatterpas/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 has to 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 (must be done via software for the HOBO loggers)

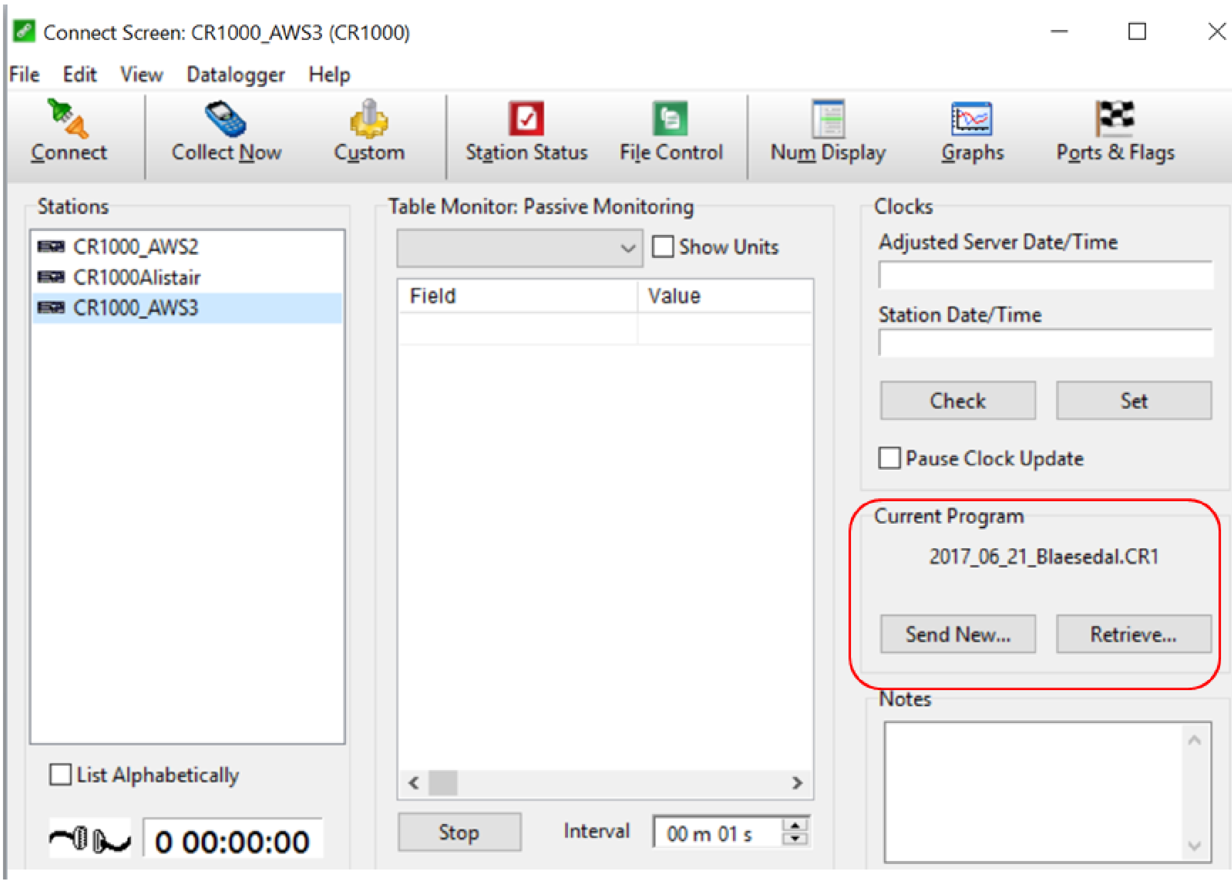
2.7 Retrieve and send program to the Campbell CR1000 data logger

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].

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.



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 on 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 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 calculated 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 (EC-1) 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. In order 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 be running year round.

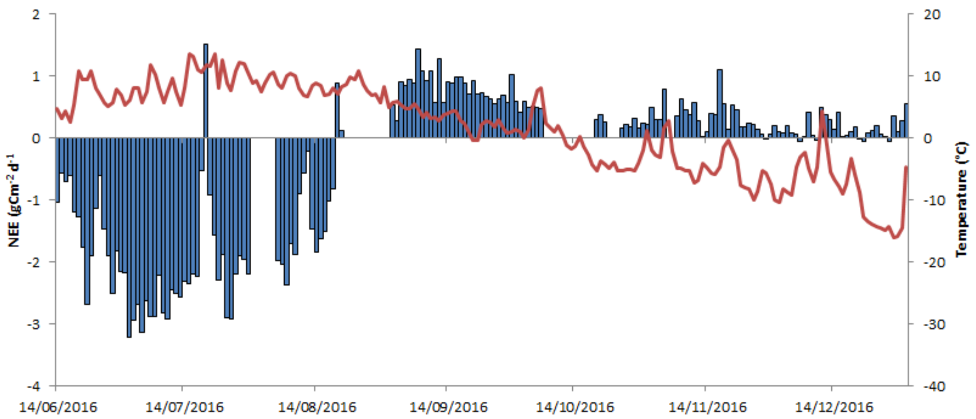


Figure 3.1. Temporal variation of diurnal net ecosystem exchange (NEE) and air temperature measured at Østerlien in 2015. NEE refers to the sum of all CO_2 exchange processes, including photosynthetic CO_2 uptake by plants, plant respiration and microbial decomposition. Fluxes directed from the land surface to the atmosphere are positive (i.e. a net release of CO_2 from the land surface to the atmosphere), while fluxes directed from the atmosphere to the land surface are negative (i.e. net uptake of CO_2 by the land, from the atmosphere).

Where to find data in the GEM Database

Program: GeoBasisDisko, **Program group**: Gas Flux, **Group-element**: EC1.

3.2 Gas flux monitoring in Østerlien

The Eddy mast (EC-1) is part of the Automatic Weather Station AWS2 in Østerlien (see section XX for more information about AWS2 and Østerlien). The eddy covariance system (Figure 3) 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-7200 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.

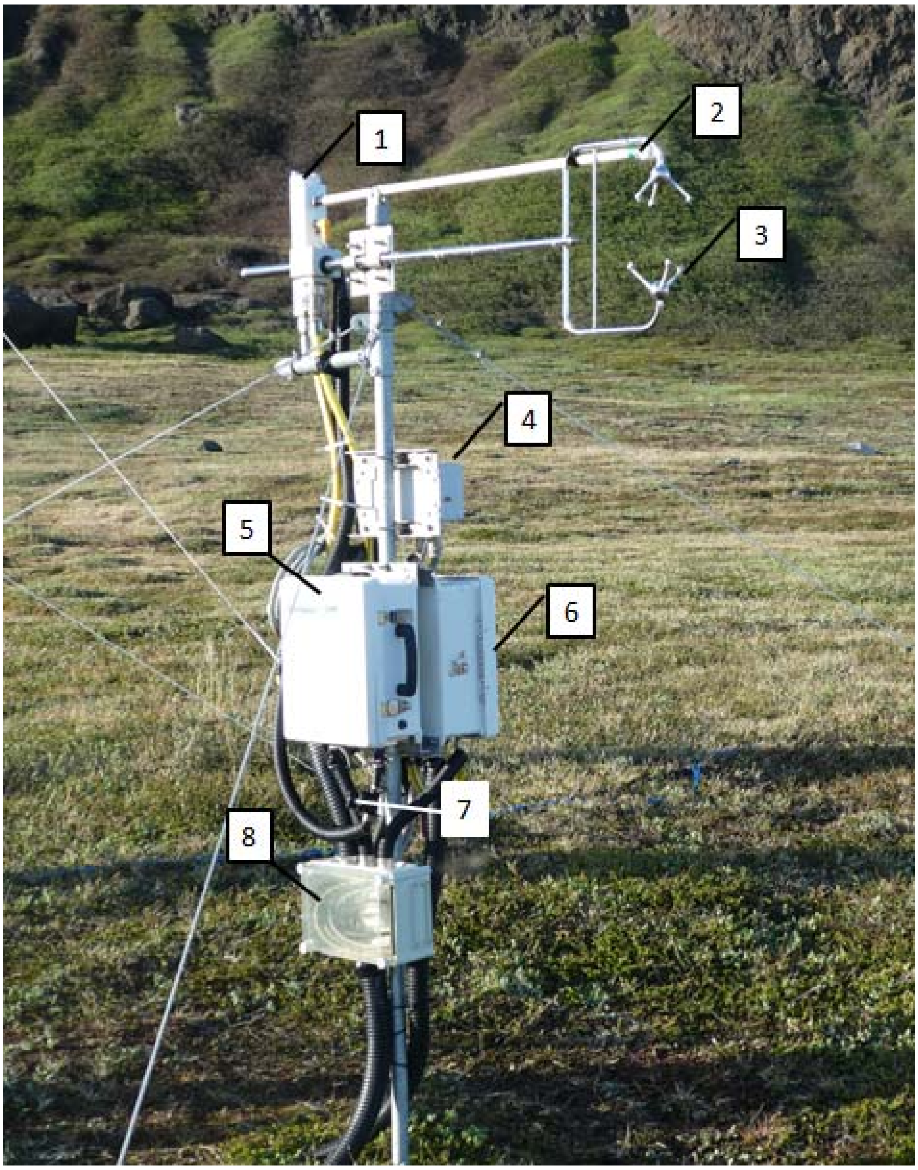


Figure 3.2. The Eddy covariance mast (EC-1) in Østerlien. 1) Licor 7200, 2) Air intake 0.25'' (inner diameter 0.21''=5,334 mm, 3) Sonic anemometer, 4) GILL Interface Unit, 5) Flow module, 6) Analyzer Interface Unit (AIU), 7) Water trap/filter, 8) Power supply Interface

The LI-7200 is an infrared gas analyzer with an enclosed sampling cell. It is equipped with a 1-m air intake tube, terminated by an intake cap and filter in order to prevent rain and dust from entering the analyzer optical path. The intake cap is attached to the frame of the sonic anemometer for keeping it stable. Air is continuously pumped to the gas analyzer by the flow module at an average flow rate of 10 lpm (liter 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).

Lower on the mast is a power supply interface protected in a plastic box. All power cables are plugged in the Power supply complex, a few meters away (Figure 2). The white enclosure at the Power supply mast also houses the Gill Power and Communication unit, which is used to switch on or off the anemometer as well as for direct communication with the instrument via serial connection.

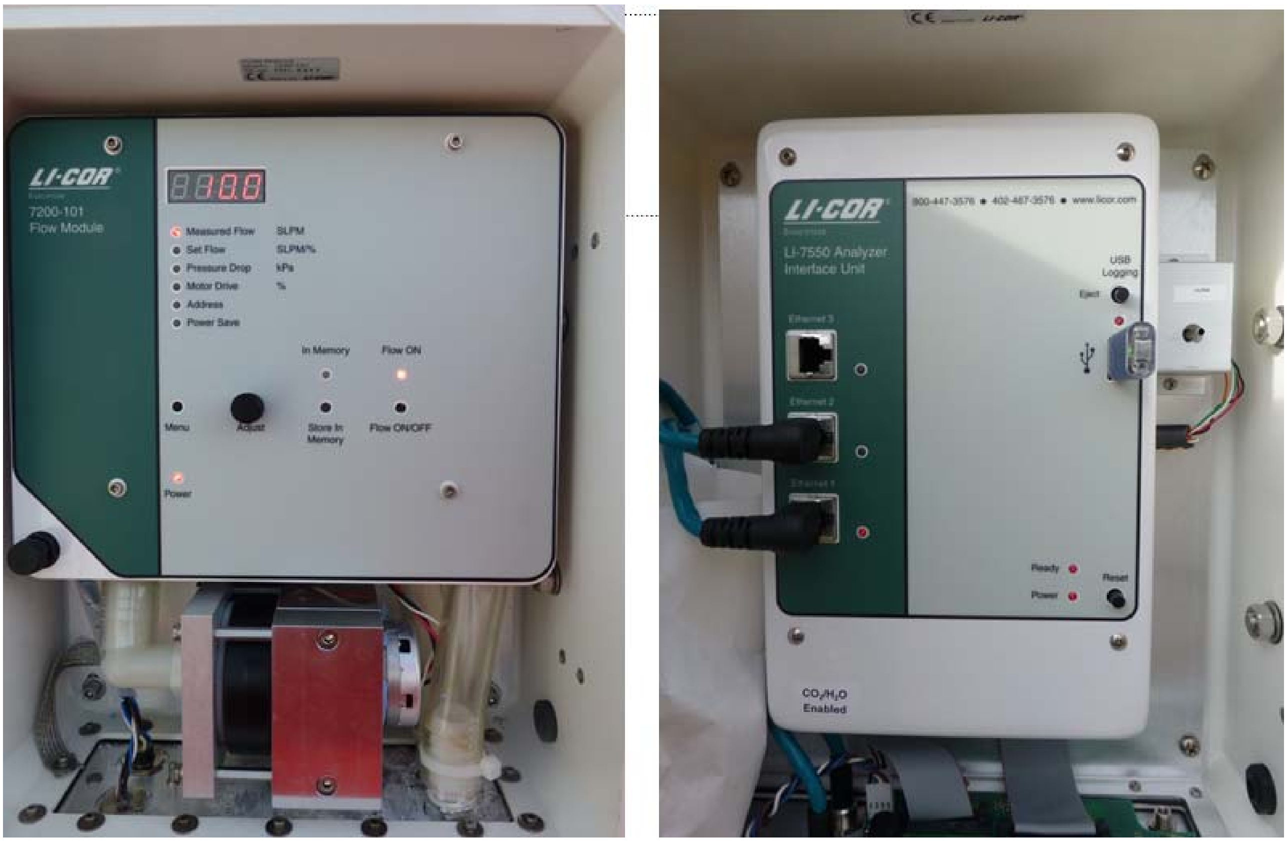


Figure 3.4 Flow module LI-7200-101 (left) and Licor Analyzer Interface Unit AIU LI-7550 (right) inside the white enclosures on the mast


Figure 3.5 GILL Power and communication Interface. On/OFF botton is located on the front panel of the box /interface (pointing down on the photo)

3.2.1 Offloading data from the EC tower (PC)

The data from the eddy covariance mast is logged continuously on the garage computer via the LICOR software and copied to a Dropbox. Data from AWS2 and EC1 is automatically transmitted and can be remotely accessed. The software automatically writes 30 min-long files in .txt format in the following folder: C:\Users\Eddy\Dropbox\AS Disko Oesterlien\Scheduled collection\LiCor\

Name	Date modified	Type	Size
LogFile-2017-11-17T043000.txt	17/11/2017 09:00	Text Document	6,360 KB
LogFile-2017-11-17T050000.txt	17/11/2017 09:30	Text Document	6,356 KB
LogFile-2017-11-17T053000.txt	17/11/2017 10:00	Text Document	6,354 KB
LogFile-2017-11-17T060000.txt	17/11/2017 10:30	Text Document	6,373 KB

1. Once a week, data are copied to a university backup drive by the reference person. The destination folder is I:\SCIENCE-CENPERM-DATA01\Arctic Station\CO2 flux mast\YYYY.
2. When confident that all data are copied to the backup drive, delete the files from the Dropbox in order to free space. If the Dropbox is out of space the files are still saved on the local computer in the garage at Arctic Station. When space is regained in the Dropbox, file transmission will resume.

Note: If files are directly copied from the computer in the garage to an external harddrive/USB then do not delete or cut them from the destination folder before confirming with the GeoBasis datamanager.

3.2.2 Offloading data from EC tower (USB)

A copy of data is also saved directly on the USB placed in the LI-7550 Analyzer Interface Unit. The USB is meant as a backup –the complete data files are stored/transmitted to the computer in the garage and offloaded from there. The files saved to the USB are compressed and contains 19 variables in each file compared to 53 variables in the computer logged files. Before the USB in the Licor 7550 Analyzer Interface Unit is full it must be replaced with another USB.

Procedure

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

2. After the USB is removed, replace it with another 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 error (figure 3.6). 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 re-launch system)

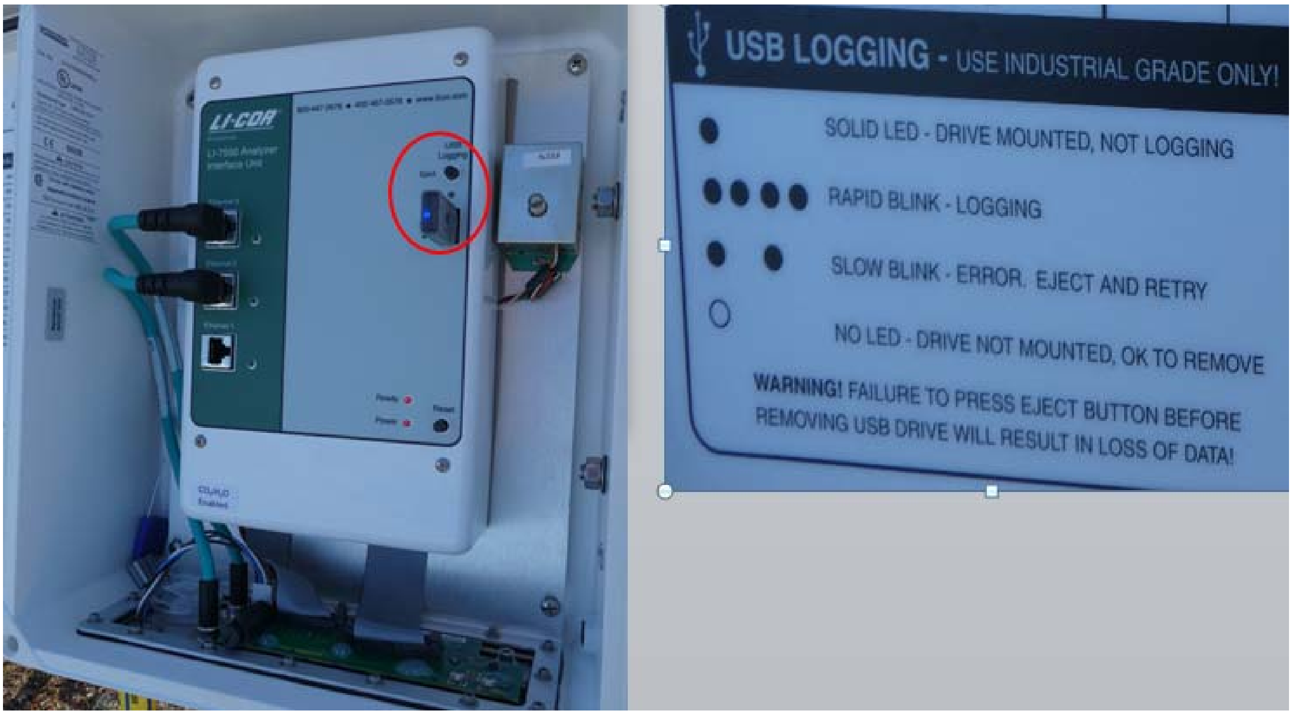


Figure 3.6 Position of the USB in the Analyzer Interface Unit LI-7550 (left) and info about the LED blinking

3. Data from the USB must be copied to I:\SCIENCE-FS-AS\Monitering ved Arktisk Station\Eddy covariance mast\Østerlien before data is deleted and the USB is formatted. File name and size look like the example below

Name	Date modified	Type	Size
2015-10-03T150000_LiCor_AS_Disko.ghg	03/10/2015 16:30	GHG File	856 KB
2015-10-03T153000_LiCor_AS_Disko.ghg	03/10/2015 17:00	GHG File	833 KB
2015-10-03T160000_LiCor_AS_Disko.ghg	03/10/2015 17:30	GHG File	868 KB
2015-10-03T163000_LiCor_AS_Disko.ghg	03/10/2015 18:00	GHG File	836 KB
2015-10-03T170000_LiCor_AS_Disko.ghg	03/10/2015 18:30	GHG File	864 KB

3.2.3 Formatting a USB

- Connect the card reader with the CF card to your computer.
- Locate the disk drive in 'My Computer'.
- Right click on the drive and press [Format]. A new window will appear (Fig. 11) where you have to specify the format options. Change the 'File system' to [FAT32] and leave all other options as default values.
- Press [Start]. Click [OK] to the warning and [OK] when the format has finished.

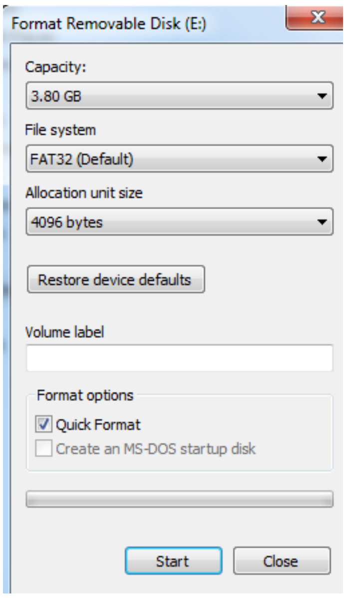
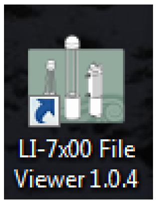


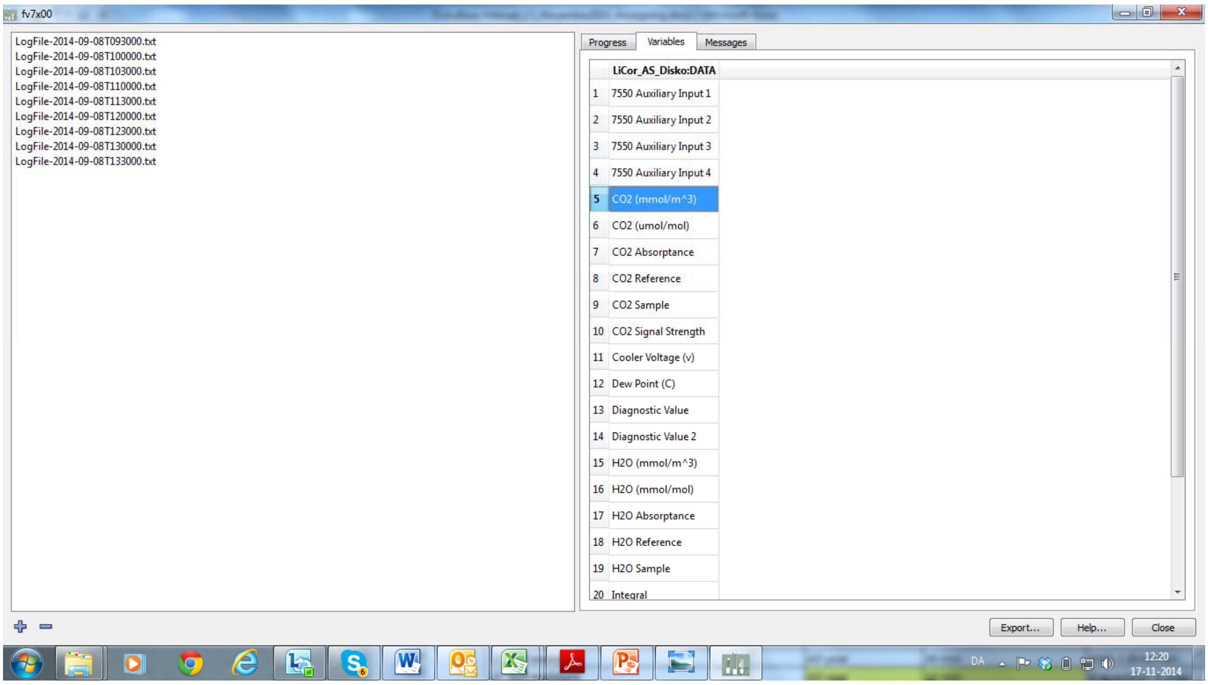
Figure 3.7: Format settings, when formatting USB

Quick validation of data

To verify that sensors are (and have been) working satisfactory prepare a worksheet with a copy of data and make charts of every parameter.

- Original files from the Eddy Covariance tower (EC1) can be viewed 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



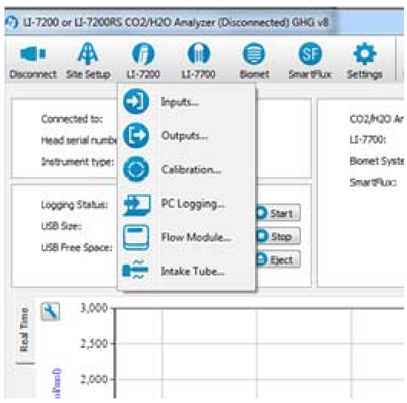


- Check that variation in parameters looks satisfactory. For an idea of the ranges for each parameter, please refer to the sheet: GeoBasis/EC-1/Østerlien/Data ranges. If anything looks suspicious or if a sensor has failures or major dropouts, please report to Data manager: Charlotte Sigsgaard (cs@ign.ku.dk)

3.3 Power off the station

If you need to power off the EC-station in Østerlien it should be done in following order:

3.3.1 Power off the Licor analyzer:



Go to the computer in the garage.

- Stop PC logging of data on the LICOR software. Find PC logging in the drop down menu under the Icon Li-7200
- Switch off the pump in the Flow module tab in the Licor software.
- Close down the LICOR software (Exit –OK).
- Go back to field. Unplug the LICOR power source in the Power supply unit (see power supply, figure 3.5)

3.3.2 Power of the GILL Sonic anemometer

Switch off the anemometer on the GILL Power and Communication Unit inside the Power supply mast (see figure 2.4)

3.4 Resuming data logging after a break

If the system has been switched off (for maintenance or any other reason), make sure that data logging resumes when the system is powered back on, as follows:

3.4.1 PC logging

1. In the LICOR software on the computer in the garage, go to the LI-7200 icon in the main menu and find PC logging (Figure 3.8). Ensure that the settings are correct.

    - Destination should be Local :C\Dropbox\AS Disko Oesterlien\Scheduled collection\LiCor\LogFile.txt
    - Update rate should be 10Hz
    - File Duration set to 30 Minutes.
    - Tick marks in all Log Values

Note: Per default the system saves data as a continuous file to C:\Users\Eddy\Documents\LogFile.txt whenever restarted. Please remember to change to the above correct settings

2. Press [Start] to resume PC logging.

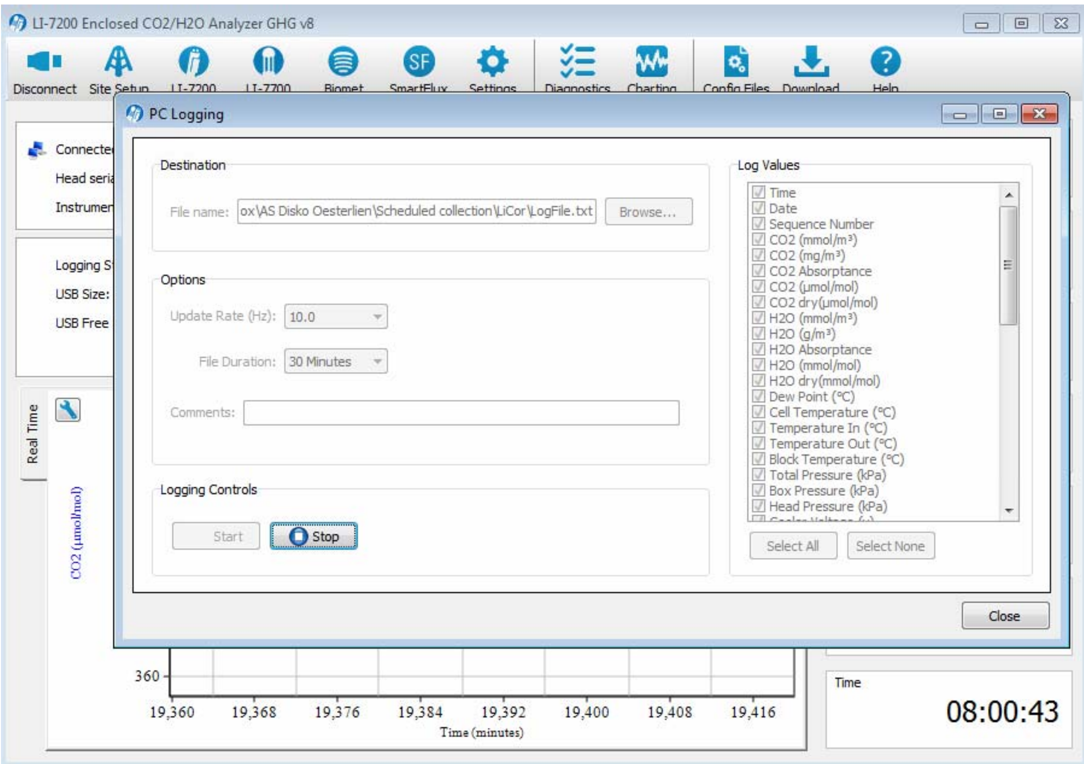


Figure 3.8 Licor window with correct settings for PC logging

3.4.2 USB logging

Select [Site setup] from the Licor software main menu on the computer in the garage. Select [USB Log File] from the drop down menu. Here the USB File options may be set/changed. Make sure that the settings are correct. Update rate should be 10Hz and File Duration set to 30 Minutes. Press [Start] to resume USB logging

- Update rate: 10 Hz
- File duration: 30 minutes
- Compress files (.ghg): tickmark
- When out of space: Stop logging

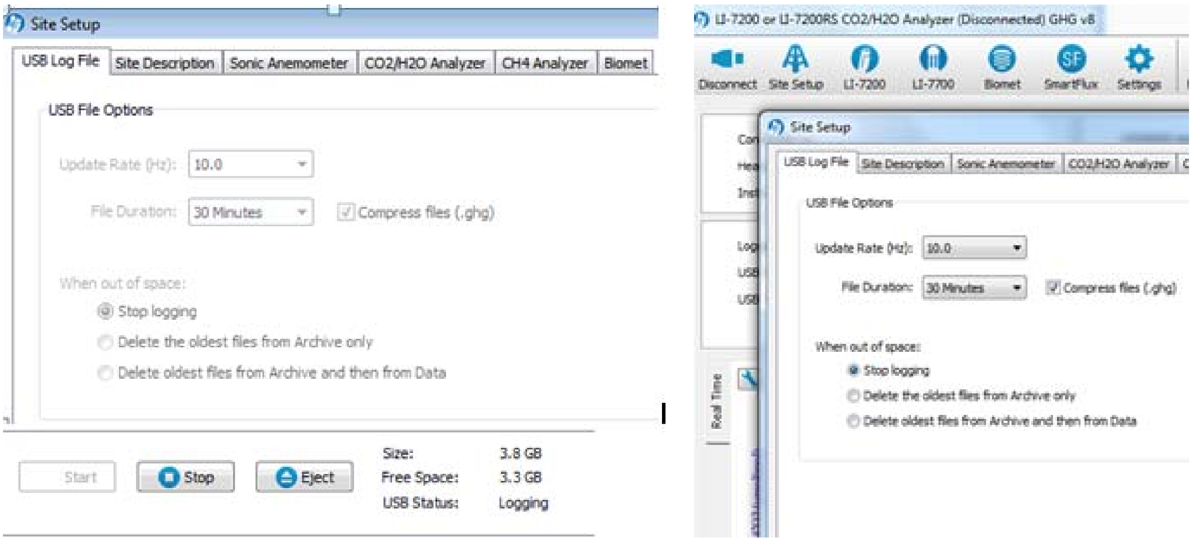


Figure 3.9. Licor window with correct settings for USB logging

Settings

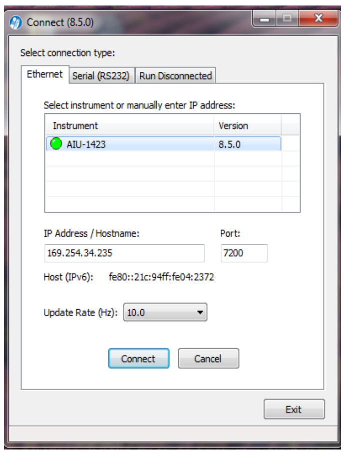
- The housing temperature is kept at 30°C since we have enough power there is no reason to change it for the winter
- The time on the Licor follow the local winter time (UTM-3) all year around

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. In Østerlien, the analyzer interface unit is continuously connected to the computer in the garage. Thus the analyzer readings can be checked at any time on the computer screen, on the main window of the LICOR software (and the computer in the garage can be accessed via TeamViewer). Alternatively, it is possible to connect to the station in the field via the free Ethernet port in the Licor Analyzer Interface Unit (Figure 3.6)

Procedure

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



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.

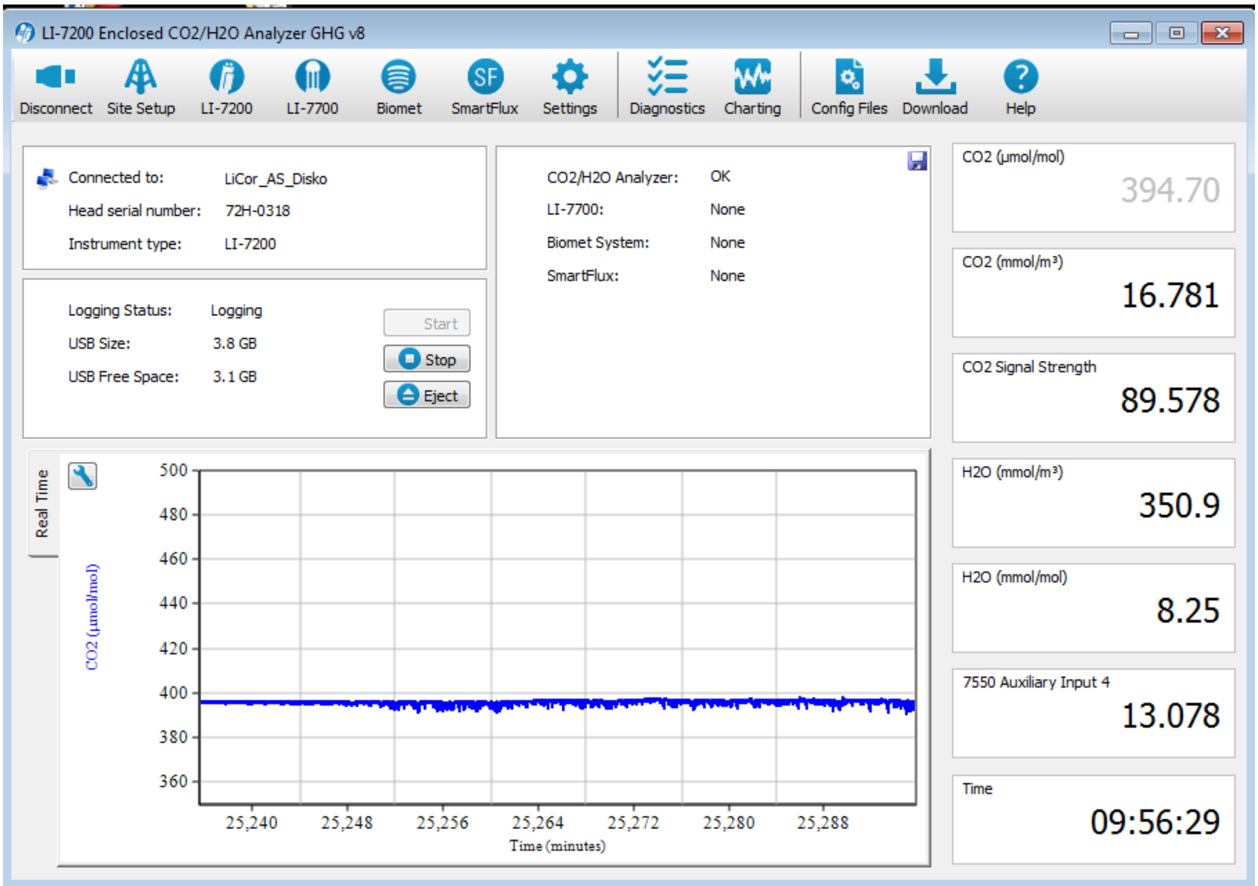


Figure 3.10. Licor main window

3.6. Maintenance

Please read through Section 5 in the LI-7200 manual, where detailed guidelines for routine maintenance of the gas analyzers are provided. And read the separate manual made for this station in Østerlien: Guidelines for the Eddy covariance station in Østerlien and Blæsedalen by Mathilde Jammet (July, 2017). 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 CO2 and H20 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)
- Change/clean filter in the air intake (3.6.5)

- 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 to the Dropbox

Every 5th year

- Change rubber tubing

3.6.1 Check the readings and signal strength from the Licor

- Check the readings of the instrument via the LICOR interface software. In Østerlien, this can be done on the logging computer that is in the garage. Check that CO_2, H_2O, temperature show reasonable values.
- Check the CO_2 signal strength. Take note of the readings in the logbook. If the signal strength has decreased by >10 points since the last logged value, you may need to clean the optical path.

3.6.2 ZERO and SPAN check of the Licor

- Perform a zero (CO_2, H_2O) and a span (CO_2) check of the LI-7200 (see section 4.3.3 in the Manual: Guidelines for the Eddy covariance station in Østerlien and Blæsedalen by Mathilde Jammet (July, 2017).

3.6.3 Calibration of the Licor (ZERO and SPAN)

- Follow the procedure given in the Licor 7200 manual and section 4.3.4 in Guidelines for the Eddy covariance station in Østerlien and Blæsedalen by Mathilde Jammet (July, 2017).

3.6.4 Replace internal chemicals

- Preferably in spring or at the beginning of the summer: replace internal chemicals in the analyzer. Clean and change the intake filter of the LI-7200. 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/clean filter in the air intake

- Follow the procedure given in the Licor 7200 manual and in the separate sheet/manual: 7200_Intake_Cap_-_Dust_Filter_Install_Guide.pdf in the directory: GeoBasis/Manuals/Licor. If you need to change the filter: find a spare part in the lab (photo). Unmount the intake from the LI-7200 (see Manual for detailed directions for unmounting the intake tube). You will need a screw driver 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, make sure to cover the upper window with an opaque cloth or with your hand when the optical path is open for cleaning. Use the diluted ethanol in the GeoBasis room of the lab at Arctic Station to clean the path. A cleaning of the optical path should be followed by a zero and span check of both species and by a calibration of the instrument if the checks reveal a drift in readings.

3.6.7 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 masts. There is a paper logbook and pencil in the interface unit box (LI-7550). Please note any visit and replace the notebook in the box. Take photos of the book (or take the book home until next visit) in order to update the electronic log following your visit. The electronic logs are found at: I:\Arctic Station\EC_stations_Disko\Oesterlien\Log\AWS-2_Oesterlien_FluxMast_LogBook.xlsx
- All manipulations and changes should be logged in the Maintenance sheet along with date and time. Please also precise the time zone (e.g. Dailight Saving Time DST, Local winter time or logging time). Since the EC systems log data on different clocks, noting the time reference is important when analyzing fluxes later on, e.g. to be able to track back a peculiar behavior.

The electronic logbook is an Excel file composed of 4 sheets: Site Infos; Maintenance; Zero and span checks; Calibration. The Maintenance sheet is where any observation, change or activity should be logged along with date, time and 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).

Pictures - Taking pictures can be a valuable and helpful additional documentation to any change, manipulation, observations or calibration. Whenever possible, document the changes and status of the set-up in picture. The pictures should be then copied accordingly in the Log folders:
I:\Arctic Station\EC_stations_Disko\Oesterlien\Log\Pictures\
Create a new folder and name it as the date when the pictures were taken, so that one can refer to it when reading the electronic log.

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 gasses such as carbon dioxide (CO_2) and methane (CH_4). Snow have a major impact on the below snow environment due to the insulating properties providing stable thermal conditions. However, the winter snow cover also has a direct impact on ecological 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 fall as snow.

Local intro:

Around Arctic Station snow can be observed during any month of the year. In general a continuous snow cover in Østerlien is established in October and melted in May/June. However, large annual variations are observed.

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: GeoBasisDisko, **Program group**: Snow, **Group-element**: Snow depth/Snow density/

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. <u>This camera has been removed and images are now captured by a camera mounted on the garage roof</u>

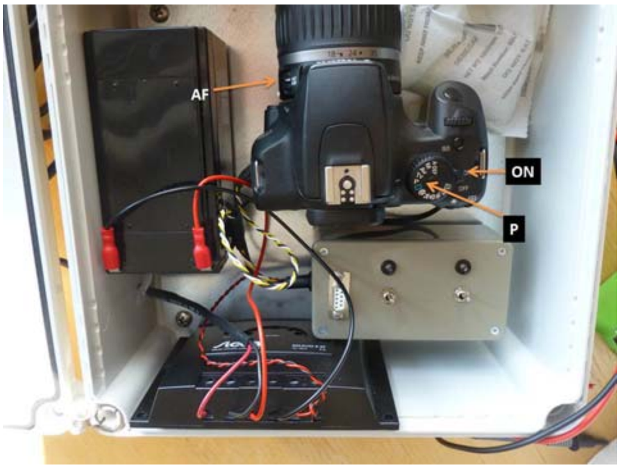


Figure 4.1 Automatic camera installed behind Arctic Station. The camera points towards east, looking at Østerlien.

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 (figure 3.2)

Position: 69,253646mN, 53,516639mW

Elevation: 28 m asl

Camera has been operating since: 2012

Camera: Canon EOS

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

1. Undo the Fibox plastic screws with the screw driver 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. Be careful to close the card holder door, otherwise the camera will not take photos

3. Test the camera by firmly shifting one of the control switches on the trigger box (maybe you have to 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 3.1.2) 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

Time settings on the camera are set for West Greenland Wintertime (GMT-3). Select [P] on the program wheel and [auto] for ISO, aperture and shutter speed. File format is set to RAW.

Trigger box: The box must also run West Greenland Wintertime (GMT-3). From April to October photos must be captured at 9, 12, 15, whereas in the remaining winter months only one daily photo is captured at 12. To communicate with the triggerbox please contact **Andreas Westergaard-Nielsen**

	Hour	First month	Last month
Trigger 1	9	4	10
Trigger 2	12	4	10
Trigger 3	15	4	10
Trigger 4	15	11	3

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

In 2015, a digital camera was installed at Lyngmarksfjeldet in order to improve the sea ice registration. Now, daily photos of the sea ice situation are captured automatically. Photos make it possible to follow ice mountain drift, sea ice cover formation and break-up in the Disko Bay area outside Qeqertarsuaq.

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: N 69°16’17’’ W,53°32’48’’ Elevation: 385 m asl

Camera has been operating since: 2015

Camera model : Canon EOS 6D

For offloading please refer to Andreas Westergaard-Nielsen

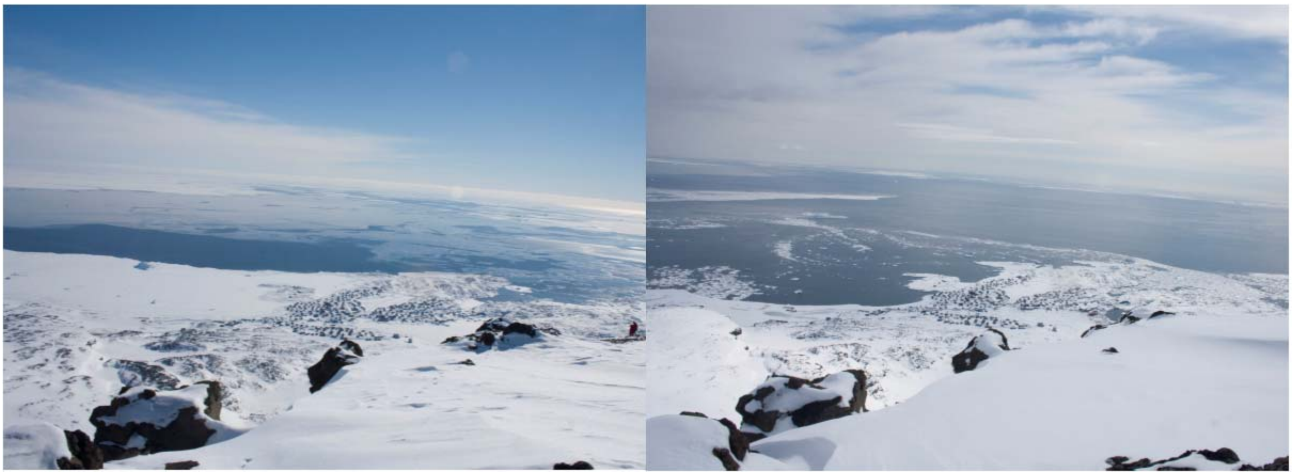


Figure 4.4 Photos captured by the camera at Lyngmarksfjeldet 19-04-2015 and 19-05-2015

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. 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. Since there might be ice at the soil surface or ice layers in the snow you might not hit the ground/soil surface – therefore, we need to have the distance from sensor to surface

4.4.2 Snow depth measurements using MagnaProbe

In order to extend the number of point measurements for a better spatial coverage of the snow cover, 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 leaders house. The pattern is shown in figure 4.5.

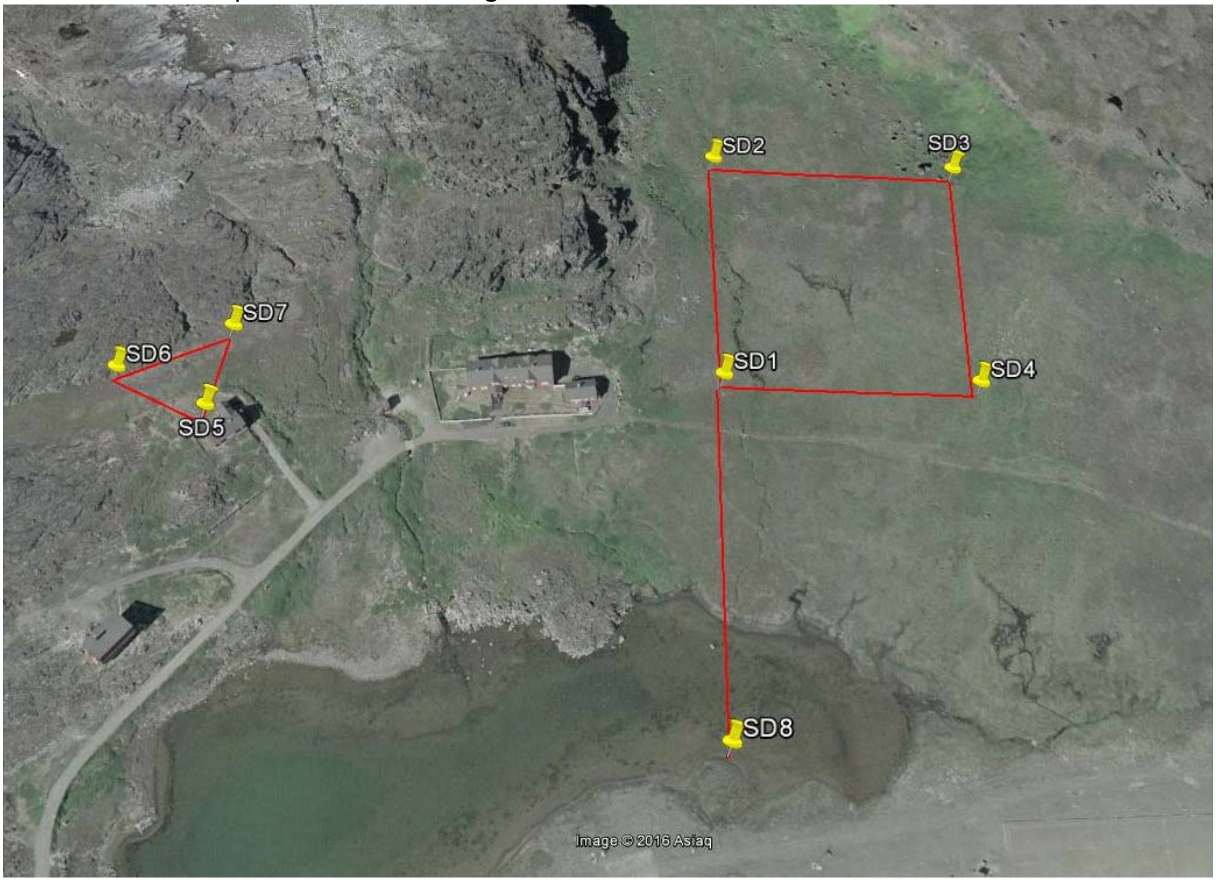


Figure 4.5. Transects/Pattern for snow depth measurements

Frequency

In November, February, 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 back pack)
- Magnaprobe Info slides
- Folding rule, measuring tape
- Field sheet/logbook
- GPS with fix points for SD1 to SD8
- Skies with skins/Snowshoes
- Digital camera

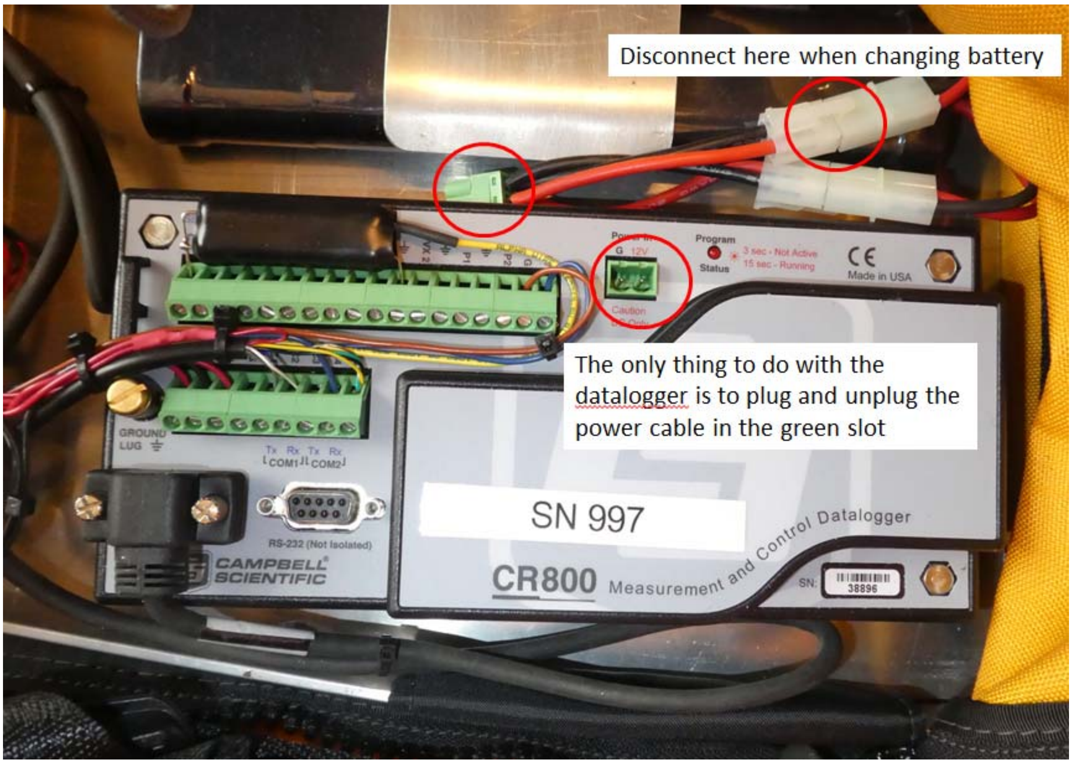


Figure 4.6 Campbell CR800 datalogger inside the backpack

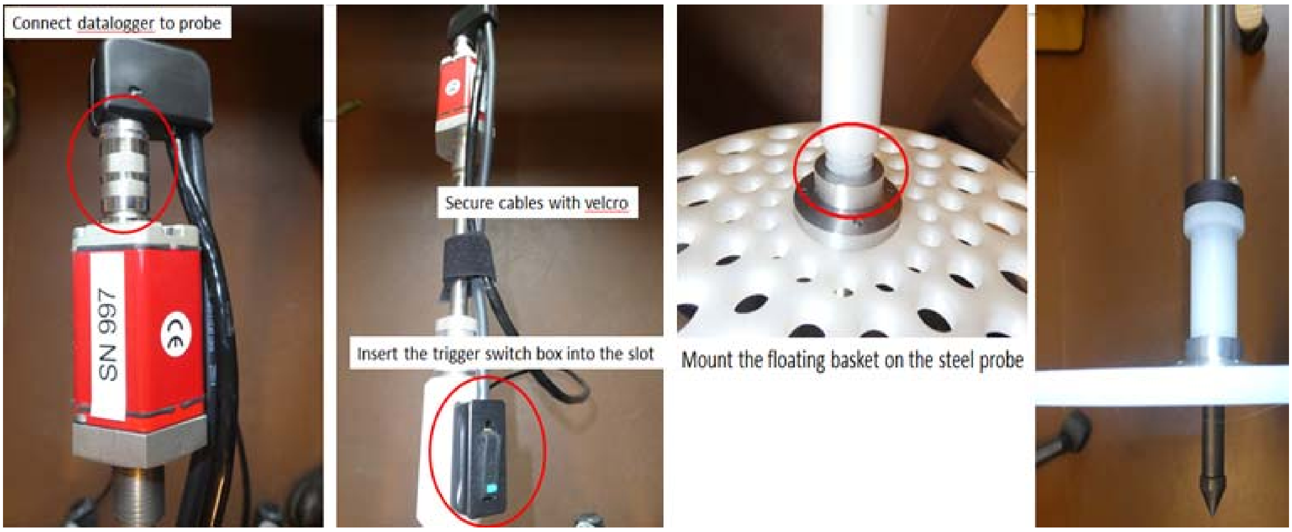


Figure 4.7 How to connect and prepare the probe

Figure 4.8 Equipment for charging and the 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 back pack.

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/snow shoes? Do you get wet boots?) etc.) 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 snow pack, -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. Snow depth more than 1.2 m is 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 snow pack 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.

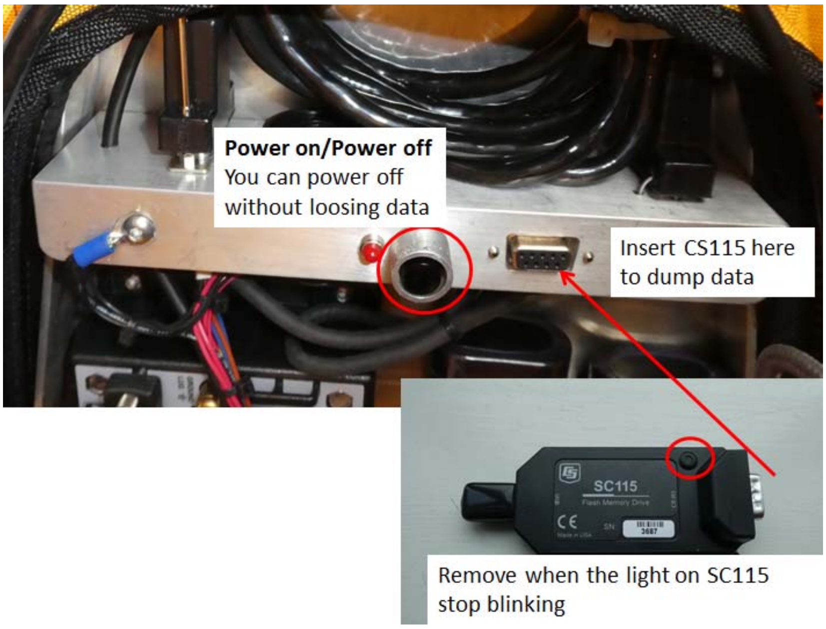


Figure 4.9 Offloading data from CR800 Magnaprobe datalogger

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:SN99	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 both measured in snow pits where densities are determined for different layers in the snow pack (section 3.4.1) and as bulk densities where snow density is measured by snow coring from the top of the snow pack (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 influence/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

1. 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 snow pack

<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

2. 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

3. Move the spatula through the snow pack (from the top of snow to the ground surface) in order 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.)

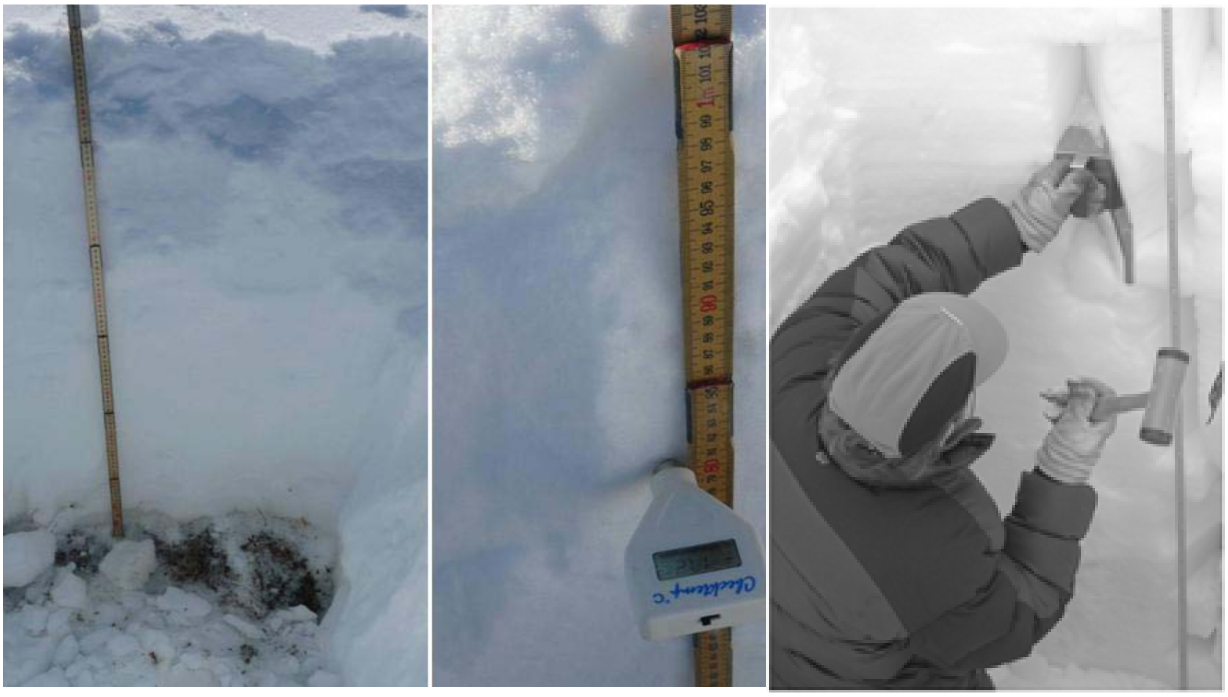


Figure 4.10 Snow pit without basal ice (left). Temperature recording (middle). Sampling of snow with a Rip cutter (right)

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

5. 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

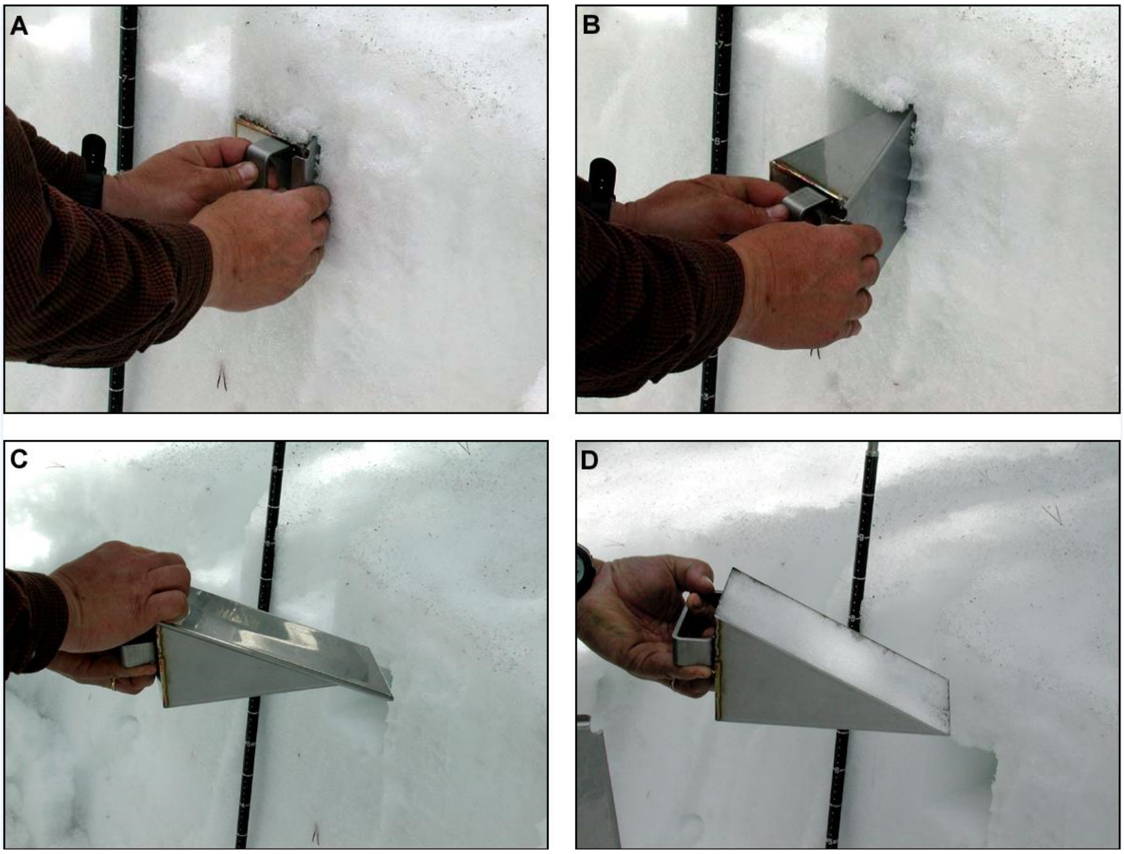


Figure 4.11 Sampling snow with a RIP- cutter

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

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

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

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

10. 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) in order to calculate an average density for each layer

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

12. Move the thermometer 10 cm further down

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

14. Remember to remove 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)	^{o}C
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*

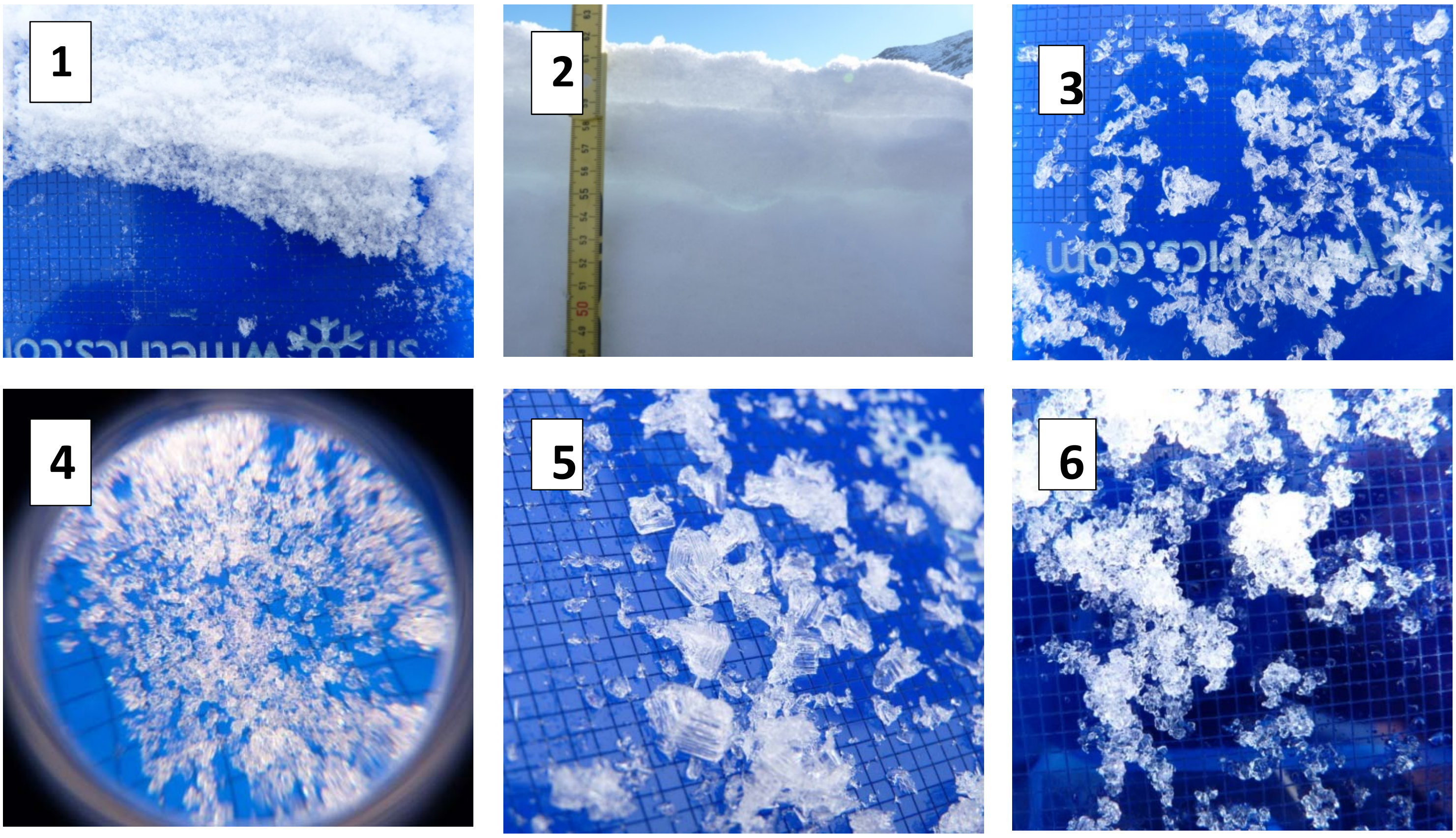


Figure 4.12: Types of crystals -see photos and see below for a description of the crystal types in the photos. Find more info about these crystal types in the snow classification in Fierz et al. 2009.

	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 UTM 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 raising the tube, read the depth of snow on the outer site 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 length 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 it is not, retake.

6. Use a folding rule to measure 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).

7. Carefully, remove the driving wrench from the tube (makes it easier to weigh the tube and to clean it).

Figure 4.13 Snow sampling tube in use. –her skal I stedet være billeder af udstyret ved AS. Klart rør, som ikke skal samles. Røret ved AS er to meter. Men ellers er fremgangsmåden den samme

8. 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

9. Carefully balance the sampling tube containing the core on the weighing cradle or on a scale (Figure 3.9). If windy, point the tube into the wind. Record the weight in the field chart. If the total snow depth is below 1 m, the snow can be transferred from the tube to a pre-weighed plastic bag and measured more accurate. If it is windy or too cold for the scale to work outside consider to bring samples into the station in labeled plastic bags and weigh inside

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

11. For each site at least 3 cores must be taken.

5 Soil /ground monitoring

5.1 Introduction

The GeoBasis program measures different parameters in the top soil/ground. In large areas of the Arctic only a shallow soil layer is covering 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 have the potential of releasing greenhouse gasses when soils thaws and stored carbon can be turned over.

Parameters measured

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

GeoBasis are monitoring 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/top soil 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: GeoBasisDisko, **Program group**: Soil, **Group-element**: SoilWaterChemistry/SoilMoisture/SoilTemp/SoilThaw

- Automatically monitored soil temperatures and soil moisture can be found under respective weather stations.

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 has been too high. Therefore, this site is no longer part of the monitoring. In order 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 in order 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 gridnet. 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 touch 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 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 have been monitored (Figure 5.4). A this site the soil was permanently frozen at the depth of 175 cm in the early 1990ties but a significant warming resulted in a thawing at this depth.

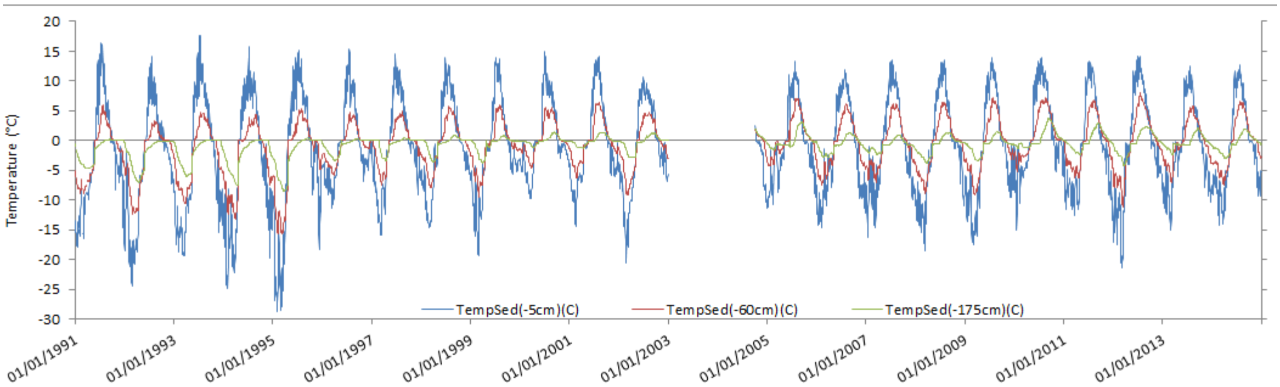


Figure 5.4 Ground temperatures measured at AWS-1 at the scientific leaders house (5 cm, 60 cm and 175 cm)

New ground temperature measurements have been included in the monitoring. There are new profiles at AWS2 in Østerlien, the deepest borehole has a thermistor at 350 cm (Figure 5.5). Data from this site shows no freezing at any time of the year at 350 cms depth. Within the area around Arctic Station there is permafrost in some areas. Southern Disko is in the zone of Discontinuous permafrost.

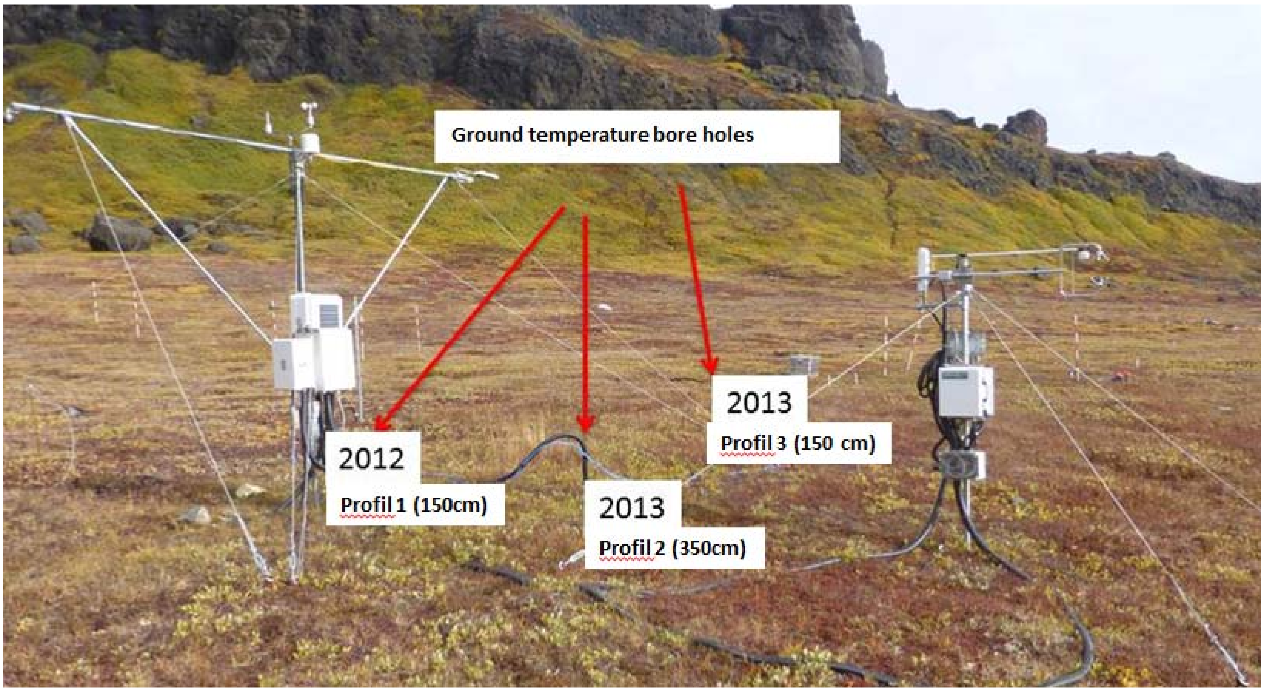


Figure 5.5 Ground temperature boreholes equipped with thermistor strings at AWS2 Østerlien

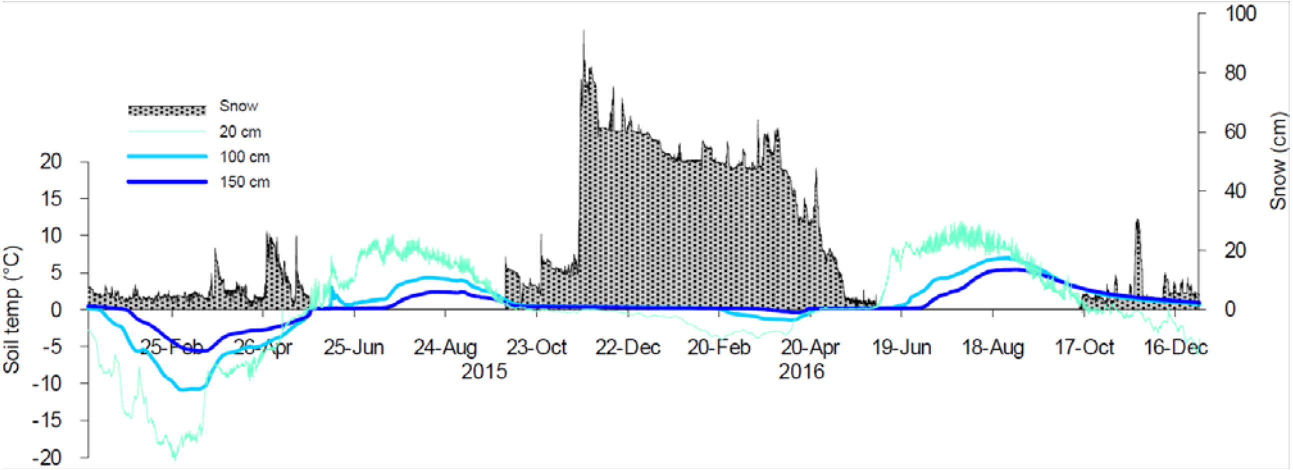


Figure 5.6. Snow depth and ground temperatures in 20, 100 and 150 cms depth in Østerlien shown for 2015 and 2016 illustrates the insulating effect of the snow. The soil/ground reached lower temperatures and was frozen for a longer period when the snow depth was low.

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

5.3.1 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 AWS-2 Østerlien, section 2.3.1 for offloading data at AWS3 Blæsedalen and 2.4.1 for offloading data from AWS4.

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 are automatically measured year-round at the automatic weather stations AWS2, AWS3 and AWS4 (for details about depth see appendix 1). During snow melt 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 also 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 may be prolonged.

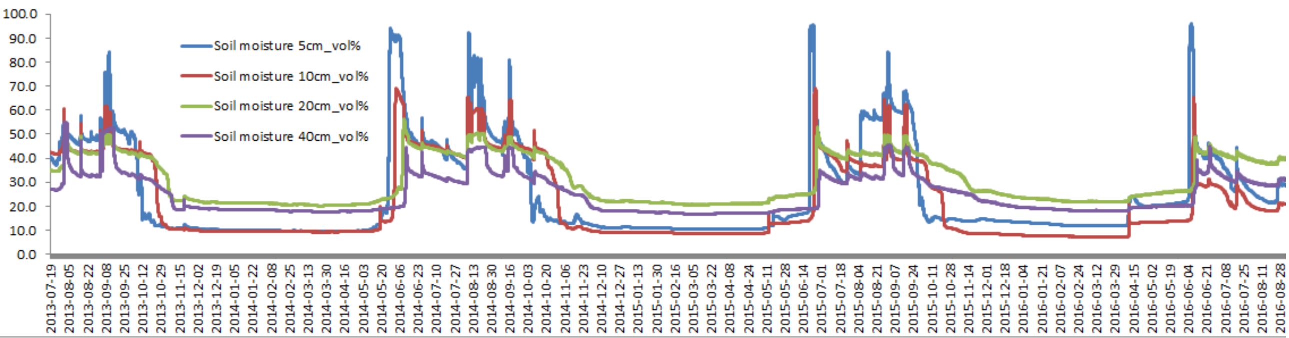


Figure 5.7 Soil moisture monitoring from AWS3 in Blæsedalen.

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 AWS-2 Østerlien, and 2.4.1 for offloading data from AWS4.

5.4.2 Manually measurements of soil moisture

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

5.5 Soil water Chemistry

Soil water is collected 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.

Frequency

From the soil thaws in May/June until it freezes in September/October soil water are being 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 every week 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/BIONitrate (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*

Location

Located c. 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: 69,25349 N, 53,51363 W
Elevation: 25 m a.s.l.
Operation: 2012-
Installation depth: 10, 20, 30, 40, 50 cm

Figure 5.8 Soil water sampling site in Østerlien

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

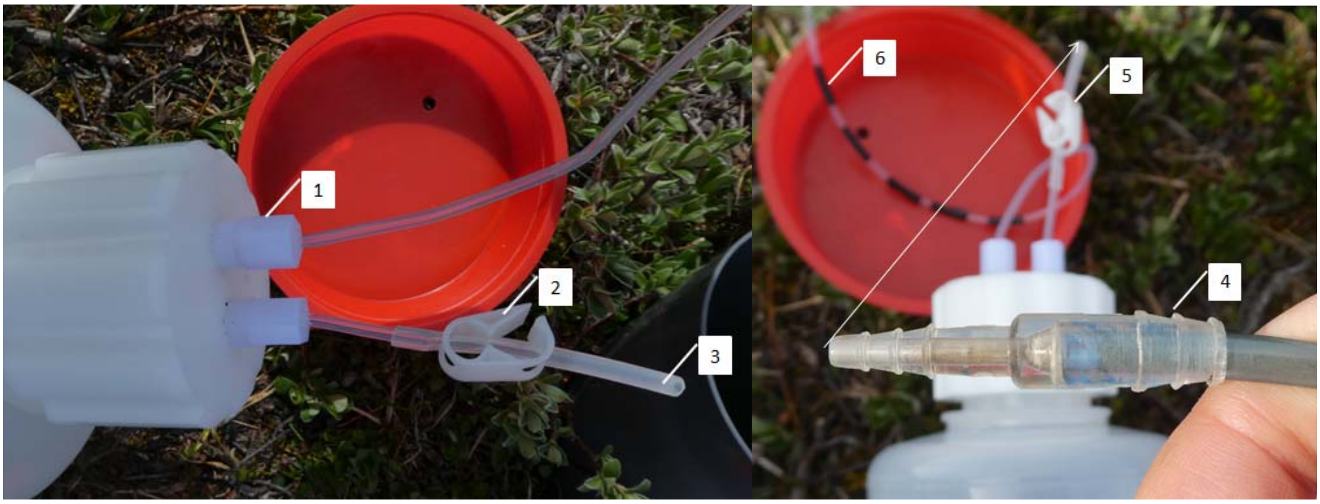


Figure 5.10 Soil water bottle (2 L) .Teflon tube from the lysimeter enters the bottle through the valve (1). Pinch clamp on the silicone rubber tube (2). The silicone rubber tube (3) is squeezed over the connector from the pump tube (4) when vacuum is applied (Remember to open the pinch clamp when using the pump and close it before disconnecting the tube from the pump)

5.2.1 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
- Metal probe/steel probe to measure thaw depth

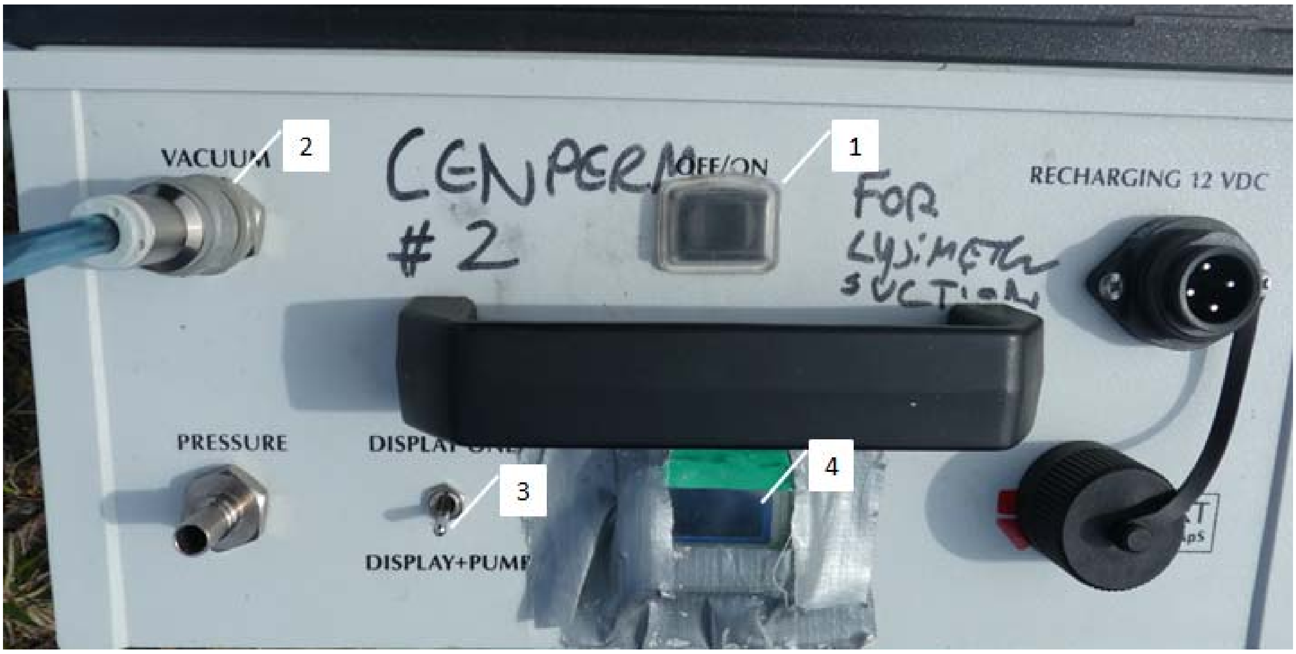


Figure 5.11 Display on the vacuum pump. Switch ON/OFF (1). Attach the tube to the vacuum hose (2). Switch to Display and Pump (3). Display showing millibar(4).

Procedure for applying vacuum

1. 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

2. Another Teflon tube is connected to the bottle and closed with a pinch clamp. Open the pinch clamp and ensure that the tubing walls are separated (figure 5.10)

3. Apply a vacuum of 300-400 millibar using the electrical pump. Discard the first few ml of water entering the bottle

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

5. Measure soil moisture at 5 random spots adjacent to the site. Avoid the area upstream 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. Remember to check if the HH2 meter is set for Organic or Mineral soil. In Østerlien select Mineral soil.

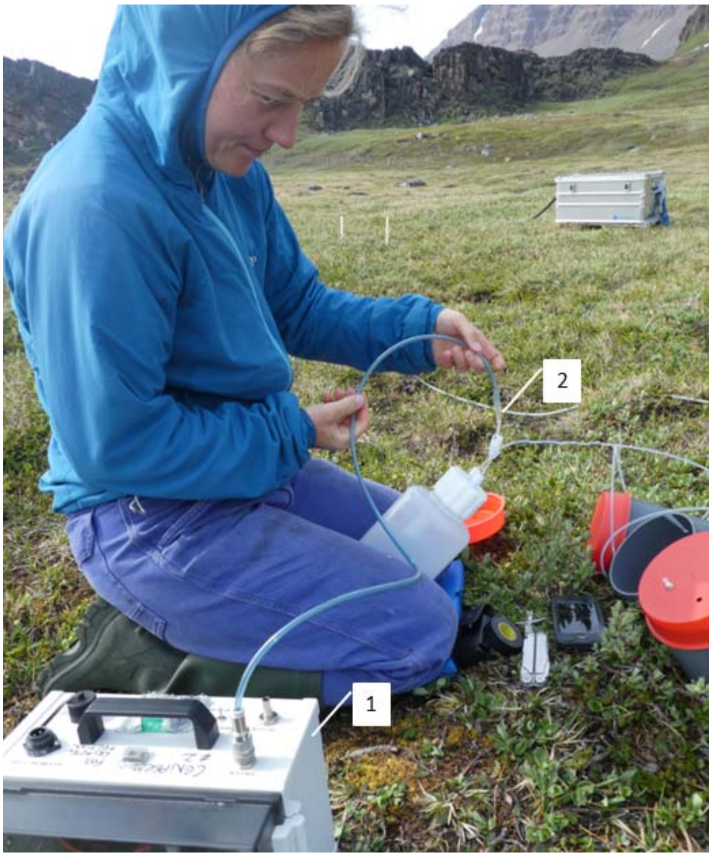
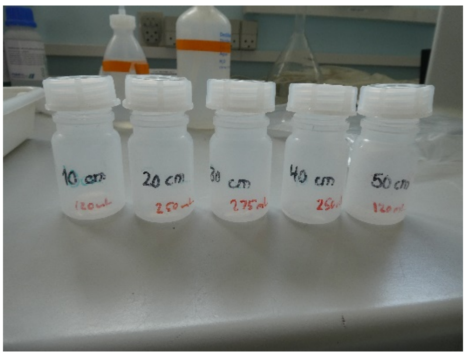


Figure 5.12 Electrical pump (1) connected to the soft tube on the bottle (2)

6. In the early season measure thaw depth at 5 random spots. Avoid the area upstream where the bottles are buried

Procedure for collection

1. Bring plastic bottles for samples (3 bottles for each depth: 10x20 ml and 5x50 ml). All bottles pre-marked with sample ID on the lid and on the vial: **SW_DDMMYYYY_XXcm** (SW=Soil Water)



2. Remove the red lid and take the 2 liter bottle with soil water. Record the approximate total volume of soil water from the scale at the bottle. <u>Note: If there is less than 75-100 ml then apply a new vacuum and write this info in the field chart.</u>

3. Record information about the soil solution (transparency, color, precipitates etc….)

4. Fill two 20 ml bottles from each depth. Pour a few ml of soil solution into the two 20 ml plastic vial. Shake vigorously and discard before filling the vials about 4/5 full (leave space for increasing volume of the water when freezing)

5. Fill one 50 ml bottle from each depth. Pour a few ml of soil solution into the two 50 ml plastic vial. Shake vigorously and discard before filling the vial with soil water.

6. If there is more soil solution in the 2 liter bottle then discard it. Close the 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 laboratory

5.2.2 Procedure in the lab

1. Store the 20 ml samples in the freezer <-18°C in a box labelled: GeoBasis Soil water samples YYYY

2. Conductivity is measured in the 50 ml soil water sample according to the procedure given in section 7.1.

3. After conductivity is measured, the sample is used for pH and alkalinity analysis. Preferably 50 ml are needed but in case of limited amounts, 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.

4. After the field season all soil water samples are brought to Denmark. One set of subsamples are brought to Department of Geoscience and Natural Resource Management, University of Copenhagen for further analysis and another set of 20 ml subsamples are brought to Institute 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
E-Mail: andersm@bi.ku.dk

6 River water monitoring

6.1 Introduction

Monitoring of the hydrology in the river Røde Elv (Kuussuaq) started in 2013 and is now a part of the GeoBasis program. 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 land to ocean. The drainage basin/watershed for Røde Elv vary in elevation from 0 to about 800 m asl and the size is estimated to 101 km^2 of which roughly 20% is glacier covered (Figure 6.1).

As part of the river monitoring a gaging station consisting of a multisonde mounted on a steel rag are deployed in the water every spring/summer. In 2015, the gaging station was mounted on a steep bedrock 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.

Manually discharge measurements are carried out in order to transform the automatically logged water level into discharge.

Besides the automatic measurements water samples are collected manually every 3rd day and analyzed for suspended sediment, major anions, cations and nutrients.

Fig 6.1 Outline of the drainage basin for Røde elv (100 km^2).

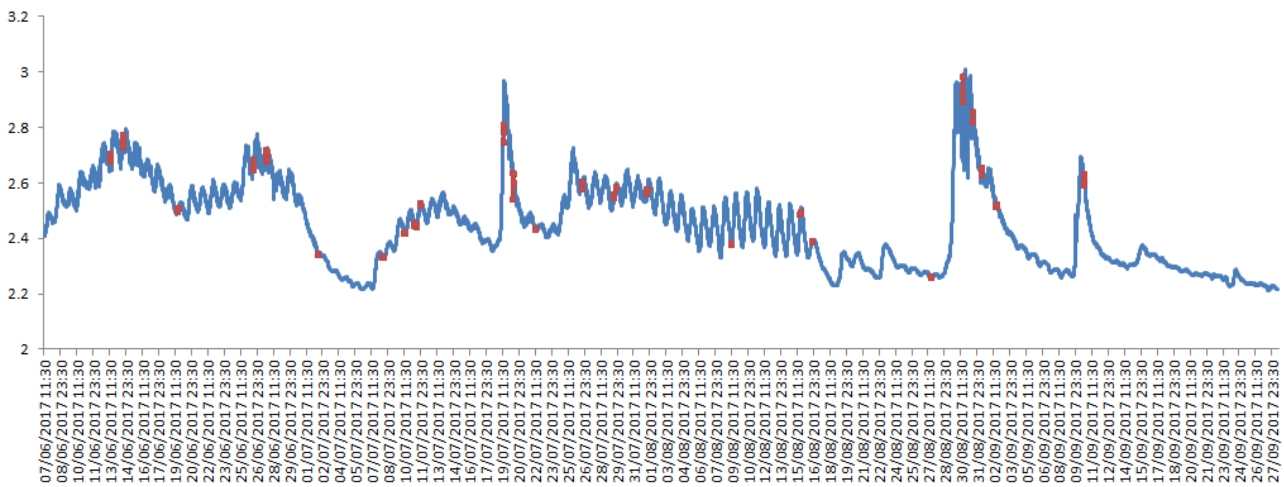


Fig 6.2 Water level variations during the main runoff season in Røde Elv (7 June to 27 September 2017). Red dots mark time where discharge measurements were carried out.

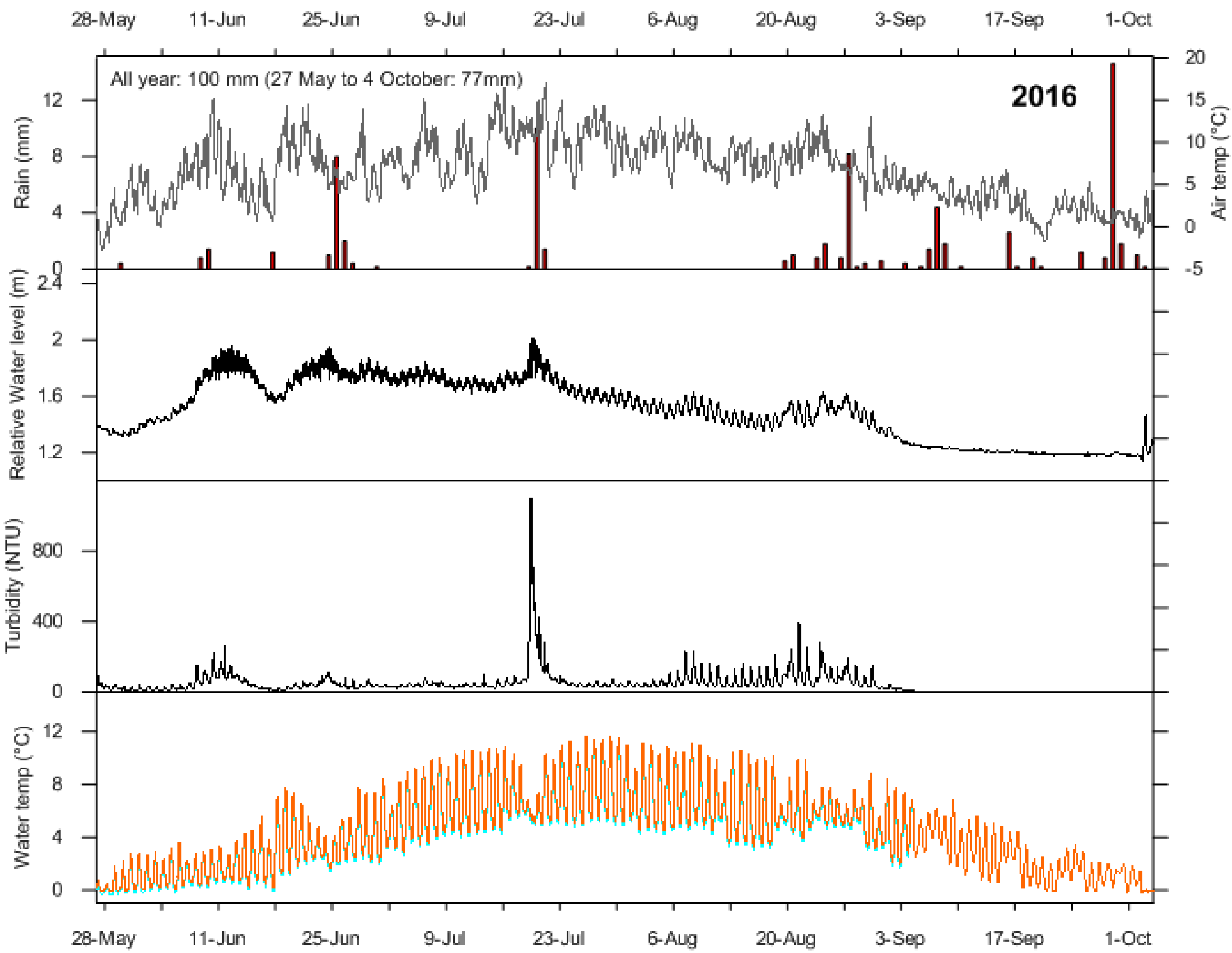


Fig 6.3 Outline of Air temperature and precipitation, water level, turbidity and water temperature in the runoff season 2016.

Parameters to be measured

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

6.2 Automatic water level monitoring

Continuous recordings of water level in Røde elv (figure 6.2) are used together with discharge calculations to estimate the total runoff from the drainage basin outlined in figure 6.1. As soon as the water starts to run in the spring (spring break up) a Multisonde and a water level logger is deployed in Røde elv. The multisonde (YSI 6820-V2) measures:

- Water temperature
- Salinity
- Turbidity
- Specific Conductivity
- pH

The water level logger (HOBO U20-001-04) measure

- Water temperature
- Water level

The Multisonde and the water level sensor are removed from the river before ice cover the sensors (late September/early October).

Location

In 2015, the multisonde was mounted on a steep bedrock north of the bridge at the eastern side of the river (figure 6.4 and 6.5)
Position (dec degrees): 69,25362 N, 53,49823 W
Elevation: 7 m a.s.l
Operation: 2015-
Time: Greenland summer time (UTM-2)
Logging interval: 15 min

Figure 6.4 Location for the Multisonde in Røde elv.

6.2.1 Calibration of Multisonde

The Multisonde must be calibrated before mounting. Use the software ECOWATCH and follow the YSI 6820 User manual and YSI-Calibration-Maintenance and Troubleshooting Manual.

6.2.2 Mounting/installation of the sonde

After river break up in the spring it is time to install the Multisonde. After calibration, transport the sonde and the steel casing to the river. The cable has to run inside the metaltube on the steel casing (see photo in figure 6.5). Mount the sonde in the steel casing inside the two P-rings and deploy the steel casing in the metal rag which is fixed permanently to the bedrock/cliff. Make sure the exact position of the sonde is measured relative to a nearby fix point.

Figure 6.5 Preparation for mounting of the sensors at the River site. A water level sensor (1) is attached on the outside of the steel housing (2). Inside the steel housing is the multi-sonde (6) mounted with P-clamps (4). Water level is measured at the circle on the multisonde (5).When sensors are mounted, the steel housing slides into the metal rag fixed to the rock wall (7). External battery (3) and communication cable is stored in the green barrel (8).

6.2.3 Start logging YSI 6820-V2

Short manual on how to program the logger: (page 2-50 to 2-53 in the YSI Manual)

- From the main menu select: **1-Run**
- From the Run menu select: **2-Unattended sampling**

Settings for unattended sampling:

1- Interval: 10 minutes
2- Start date:
3- Start time
4- Duration days

5- File: RRYYYY (Red River 2014) (Max 8 characters alpha/numeric)
6- Site: Name of no more than 31 characters –will only appear in sonde directory

- In the set-up menu: Press **C-Start logging**
- Are you sure: Press **1-YES**
- The screen will change to logging and the B-command will change to B-Stop logging, a confirmation that the logging has been initiated

6.2.4 Stop logging YSI 6820 V2

To terminate the logging

- From the main menu select: **1-Run**
- From the Run menu select: **2-Unattended**
- From the Unattended menu select: **9-Stop logging**
- Select **1-YES**

6.2.5 Offloading data from the sonde (YSI 6820 V2)

To offload/upload data (they use "upload" in the YSI manual) you need to bring a laptop with ECOWATCH software and full battery capacity. – see p 2-54 to 2-56 in the YSI manual.

Figure 6.6 Location of external power supply and cable/plug from the multisensory. A serial to USB adapter is needed when connecting to the computer

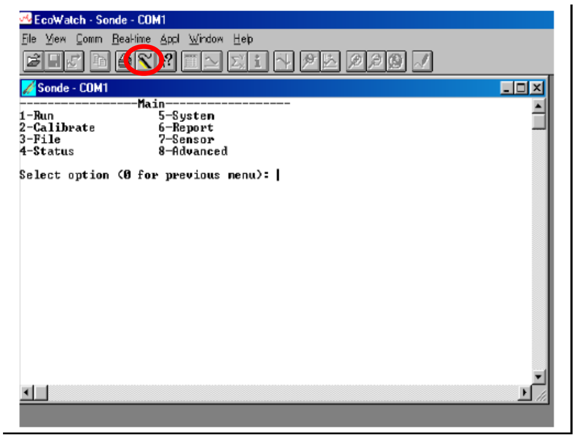
Frequency:

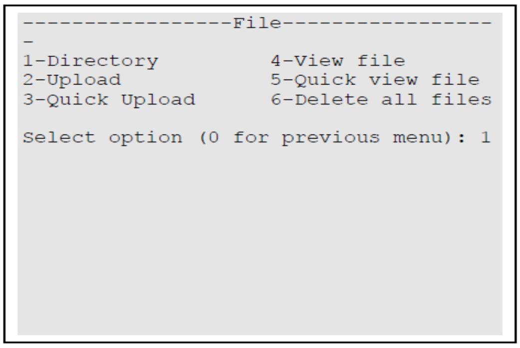
Offload data every second week or every month -whenever it is possible. It is good to be able to check data on a regular basis and also, downloading of data takes time –and if you wait more than a month or so –you need a lot of battery power on your computer. Remember to note the exact date and time for offloading data.

Procedure

1. Connect the computer to the field cable from the sonde. The cable is found underneath/below the green plastic cover together with an external battery –see figure 6.6

2. Run ECOWATCH software and select the sonde icon from the menu bar (red circle)





3. If a **#** prompt appears instead of the main menu, type **menu**

4. From the main menu Press **3-File** to view data

5. Select **1-Directory** to view all files stored in the sonde

6. Select **2-Upload or 3-Quick Upload.** Prior to upload a "Time window" appears (allow you to select portions of the logged data. To upload all data press **1-Proceed.** A Quick upload transfer the last logged file

7. Files are by default saved in the computers sub directory **C:\EcoWin\Data**

Input of data to the DiskoBasis database
Copy the retrieved data file to the DiskoBasis directory (GeoBasis/Røde elv/YSI6820/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 match 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 river bed and banks, precipitation….). Save this work file in the DiskoBasis directory (DiskoBasis/Røde elv/YSI6820/Work data/filename).

Storage of the multisonde (YSI6820) during winter
Please read section **2.10: Care, Maintenance and Storage** in the YSI manual (p 2-111 to 2-124) carefully and follow the given directions.

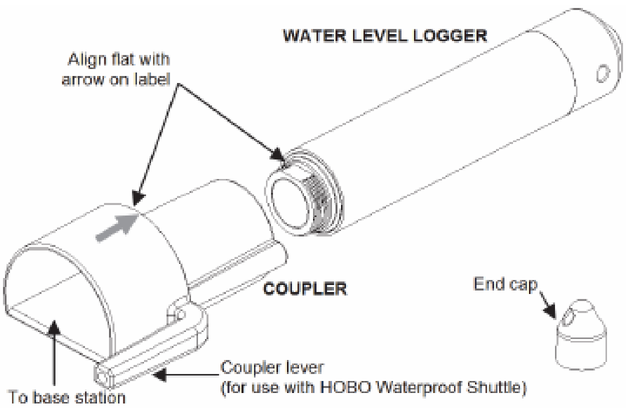
- When you have to remove the sensor depends on how deep the sensor is located below the ice and if water is still running there. The sonde must be removed from the river before ice covers the sensors.
- Download data and measure exact position of the sonde (relative to a fix point) before you remove it. Use an "ice-tuk" if you need to remove ice. Bring steel casing, sonde and external battery back to

the station. Please make sure to cover all plugs and connectors carefully before the transport –to avoid dust and sand to enter

- Perform test and calibration of the sensors before they are stored in the right solutions and with the original caps. Follow procedures given in the YSI6820 Manuals.

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

To communicate with this sensor you need a computer with HOBOware Pro and an Onset Optic USB Base Station (Base U-4) with a coupler (Coupler2-B)



1. Follow the HOBO U20 Water level logger Manual

2. 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)

Settings:

- Logging interval: 15 min
- Time: Greenlandic summertime (UTM-2)
- Sample logging
- Absolute Pressure
- Water temperature
- Battery voltage

3. The water level logger is attached to the steel case (the one housing the multisonde) with a strip and two P-rings/clamps. Note: Handle the logger carefully and do not tighten the P-clamps too much. They just need to hold the logger in position. The strip/string attached to the cap will make sure the sensor cannot escape

Figure 6.7 Water level sensor from HOBO Onset is mounted outside the steel housing (replicate)

4. Record deployment date and time

5. After half an hour measure the distance between the vertical distance between the water table and the sensor and the distance between the fix point and the water table (Figure 6.8) and record the values in the River log book.

6.2.7Offload data from the water level logger (HOBO U20-001-04)
Follow the HOBO U20 Water level logger Manual.

Input of data to the DiskoBasis database
Copy the retrieved data file to the DiskoBasis 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 match the actual time for downloading of data.

Maintenance
Battery needs to be replaced every 5 years. The logger has to be returned to Onset for battery replacement. Never try to open the logger. Only the black end cap can be removed for communication purpose.

6.3 Manual water level
At the moment, manual water levels are measured by tape ruler as the vertical distance from **Fix C** to the water table (figure 6.8). However, it is not easily accessible and a stage level must be mounted on the rock wall when possible.

6.3.1 Fix points
There are some fix points measured by differential GPS on the eastern side of the river where the hydrometric station is located. Two metal eye bolts are fixed into the rock wall. The upper one **Fix A (3.72**

masl) and the lower one **Fix B (3.66 masl)**. **Fix C (2.54 masl)** is located on the downstream side of the fixed metal rag pointed out on figure 6.8. **Fix D (3.72 masl)** is an eye bolt fixed to the rock wall on the western side of the river (where the rope is attached).

Figure 6.8 The steel rag mounted to the rock wall Eastern side. The Fix points are pointed out. Manual readings of water level is made from the 2.54 m mark to the water surface. It is the top of the V-shaped betal on the side of the rag (pointed out with a finger). Remember to point out if the reading of the distance to the water surface is below or above the Fixpoint.

6.4 Water discharge measurements

Manually measurements of the water discharge (Q) in Røde elv are important in order to establish a Q/h relation (relation between water level and discharge) or to verify the existing Q/h relation for the river.

Frequency

After the river bed and banks are free of snow, discharge is measured 5-10 times throughout the season. Especially measurements at very high and very low water levels are of interest in order to improve the Q/h relation.

Preparation of the river crossing

1. Attach the green rope/wire to the eye bolt in the rock wall (Fix A) on the eastern side of the river and the eye bolt (Fix D) on the western side of the river. The rope runs in a pulley. The distance between the two fix points are approximately 25 m (figure 6.11).

2. Attach a string with clearly visible markings for each meter next to the rope (Figure 6.11). **The western wall is point zero (0 m)** and measurements in the river must refer to this point. Make sure the string is mounted so marks on the rope are placed for each meter (first mark is 1 m from the wall and so on)

3. When the water depth is less than 35 cm use the flow meter (Valeport) and above 35 cm use the Q-liner

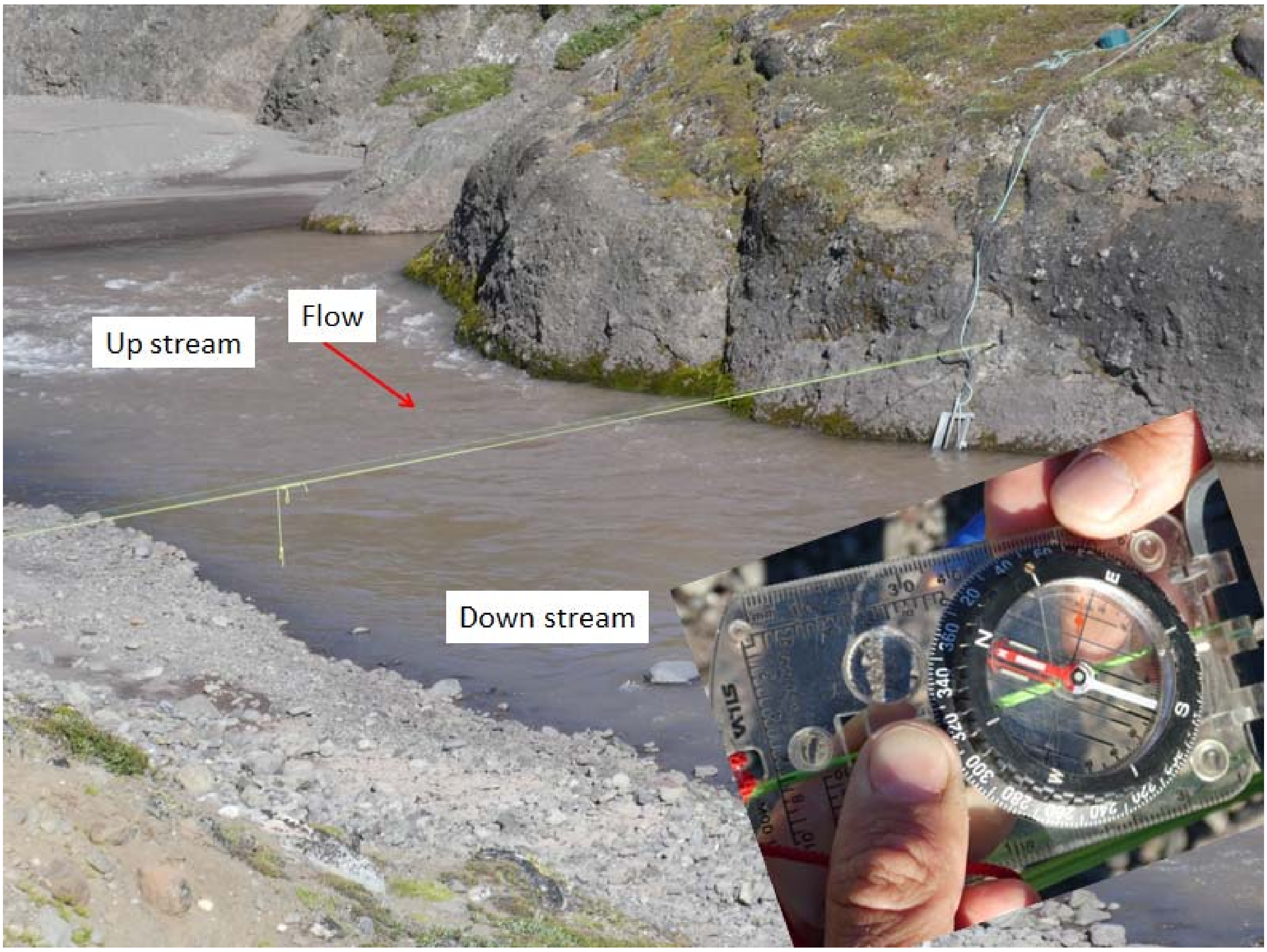


Figure 6.9 Discharge measurements are performed in a cross profile near the multisensory. The rope is attached to fixed anchors in the rock wall. The photo inserted show the compass reading of the cross-rope.

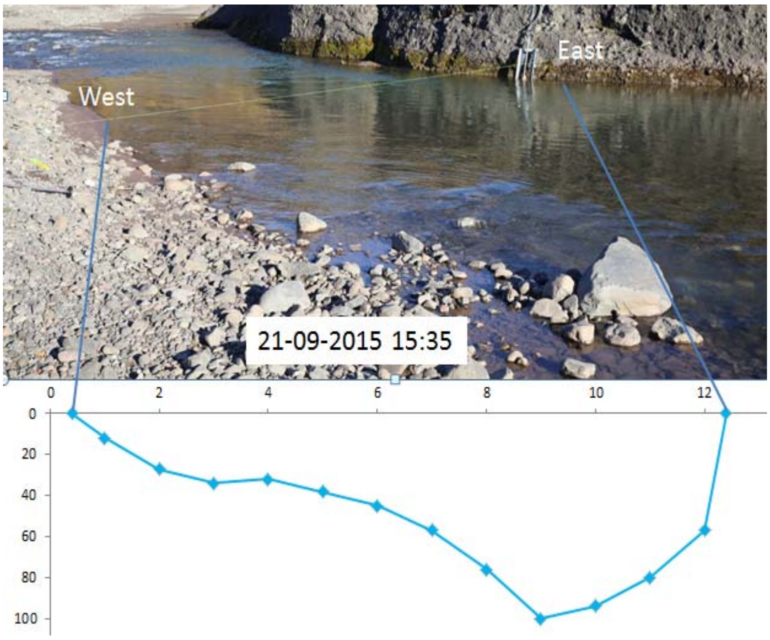


Figure 6.10 Topographic profile of the river bed, 21 September 2015

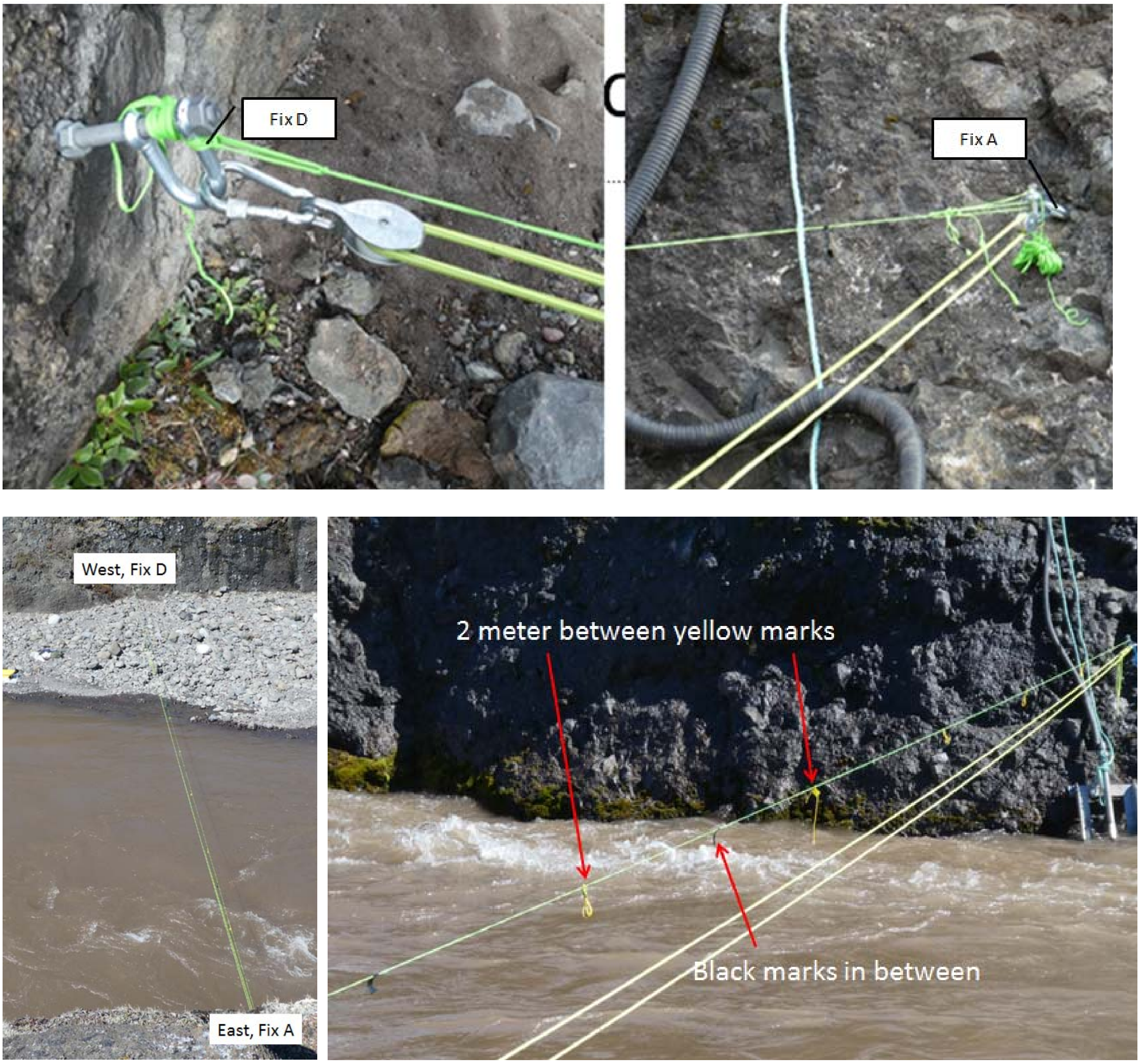


Figure 6.11 Mounting of the rope across the river from Fix D on the Western side to Fix A on the Eastern side. Next to the rope is a string with marks for every meter. For every second meter the mark is made with yellow tape and string

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 can be operated from the shore through blue tooth 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

- 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 back pack to transport the Q-liner to the river

4. Take a digital photo from the photo points (figure 6.12). Make sure the camera has the right date and time stamp!!

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).

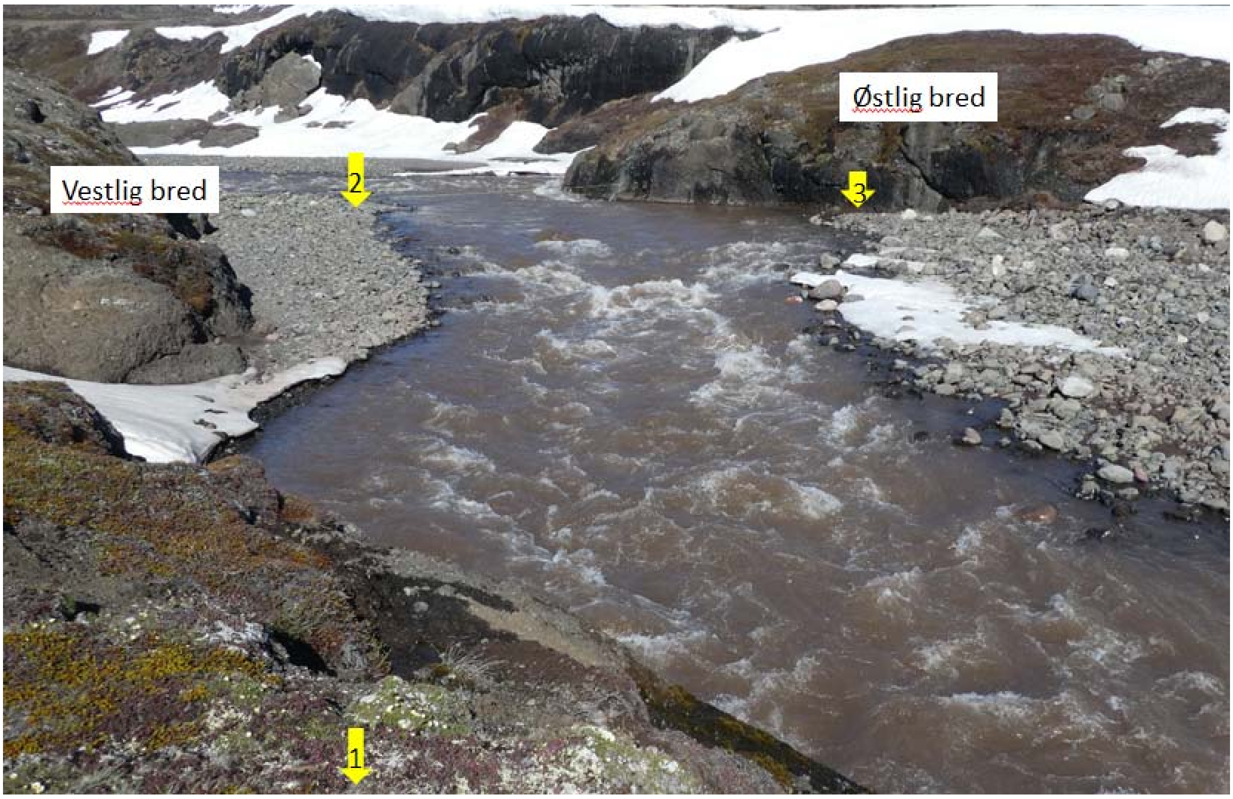


Figure 6.12 Photo points at the river site. For documentation

6. Fill out the field chart before you start. Very important to get manual measured water level at exact time

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 values 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: ja (can be changed afterwards)

Use Compass: ja (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:

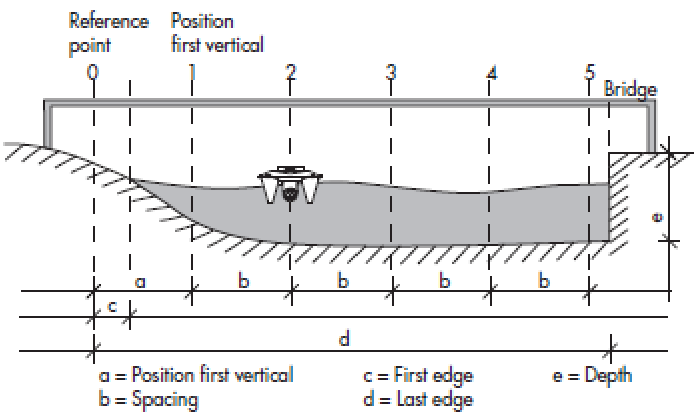
Spacing: spacing between individual verticals. 15-20 verticals is needed which means that we measure for each half meter at this site

Line Heading: Orientation of the measuring profile

Edges, First: Distance from 0-point (rock wall on the western site (Fix D) to the water line

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

Factor: 0.7



Settings> Profiler

Maximum depth: Select a larger max 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 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 correct.

3. Attach the Qliner to the loop on the rope/wire (lock the carabin!!)

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

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

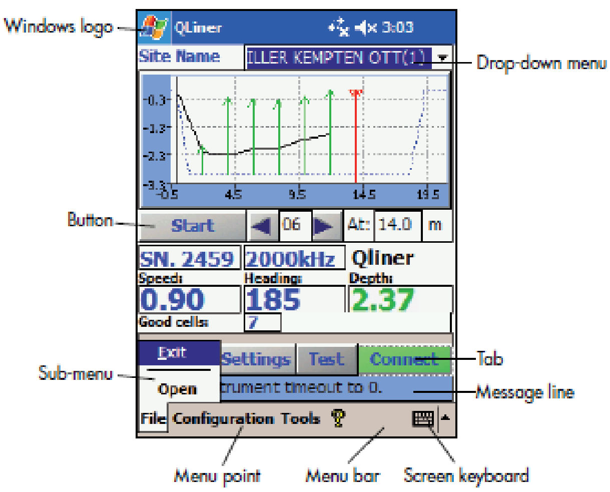
Measurement

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

2. Press Connect in the Qliner main menu

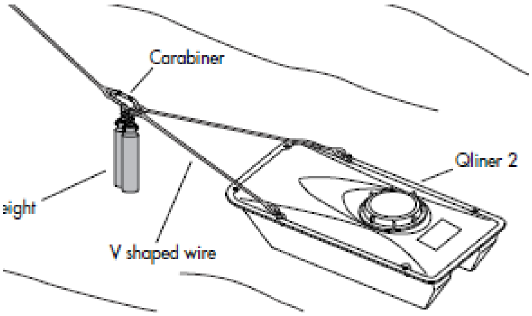
3. The system compares date and time of the PDA and Qliner. If they differ you are asked whether data on the Qliner should be synchronized with that on the PDA. Make sure the PDA has correct date and time settings (Greenlandic summertime (UTM-2)) and press OK to synchronate

4. When the Q-liner has stabilized in the first position –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 water surface. 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 rope and move the Q-liner to a position half a meter further out. 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 6.13 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. Data from measurements are saved 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**

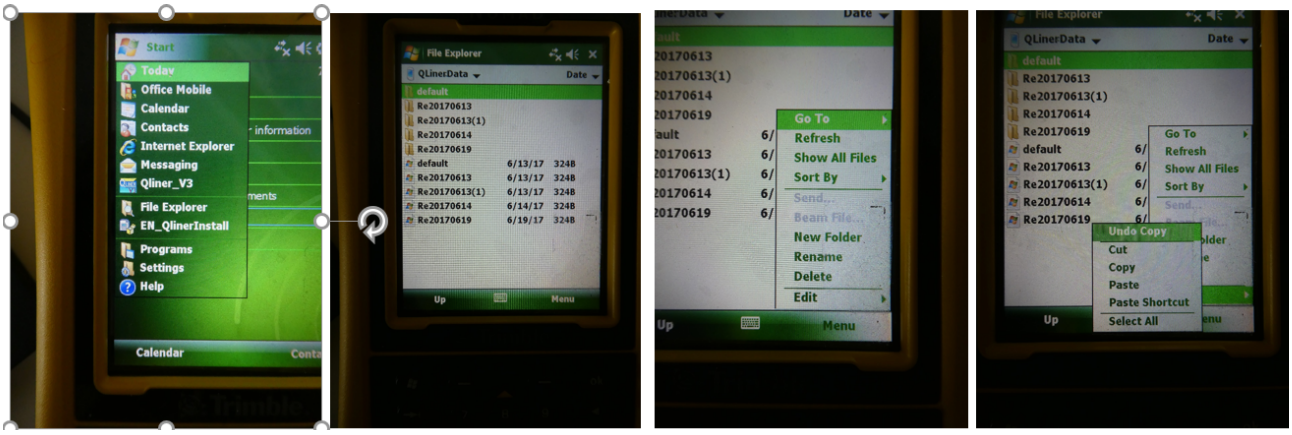


Figure 6.13 How to transfer data from the PDA to the computer

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 looks 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 and the current profiler 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 5 and 35 cm for several meters, the discharge is measured by the flowmeter at the station
- 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 Flatsensor
- Bring extra batteries (8 C cell batteries)
- Operation Manual (Valeport)
- 1.5 meter wading rod (50 cm pices in the blue cover)
- Waders
- Field chart and pencil

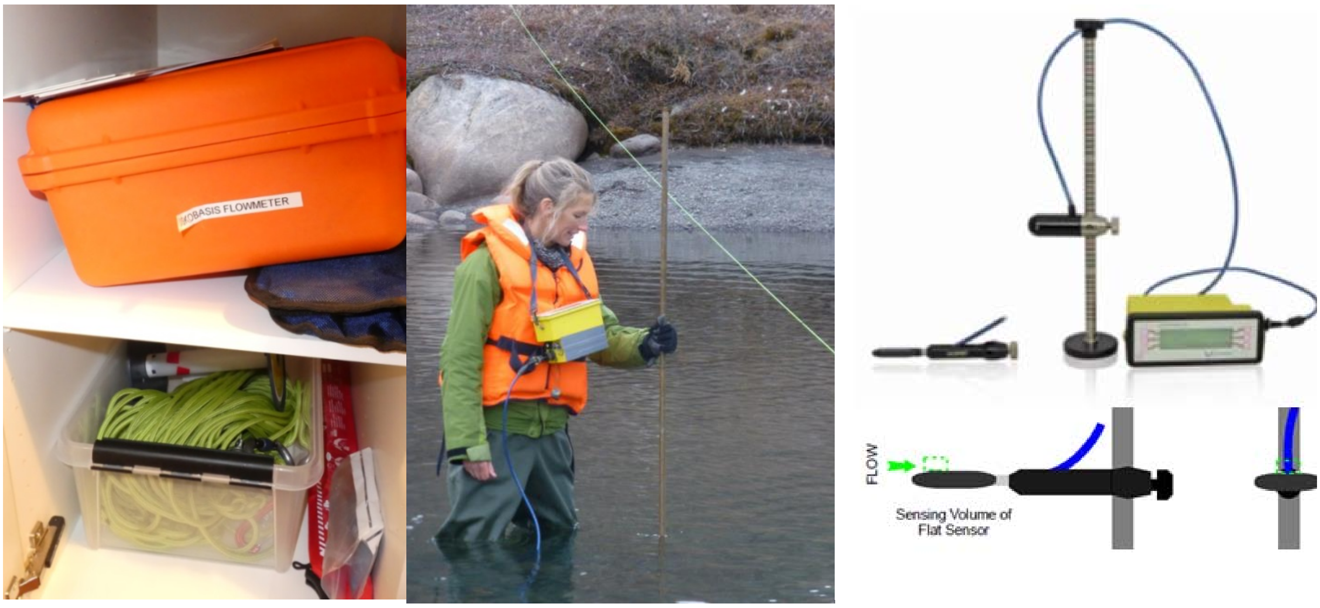


Figure 6.14 Valeport flowmeter for manual discharge measurements at shallow depth –or in smaller streams where you can easily wade across the profile

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 (Fix D on the rock wall, western site**)

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 river bed)

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 river bed and 24 cm above the river bed

Settings:

- Correct date and time (Greenland summer time (UTM-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 bee 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 in order to calibrate the turbidity readings from the Multisonde in the river. 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.

Parameters to be monitored

Sediment

- AS Suspended sediment concentration (GF/F filter)
- BIO Particular Organic Content (POC) (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 near the Multisonde by wading into the river from the western river bank of the cross section/profile (figure 6.15). If it is not possible to go out in the river the sampling is performed from the shore. Pick a site with where water flows freely (og hvor det ser ud som om der er god opblanding).

Frequency

Water samples for suspended sediment analysis and water chemistry are collected every 3rd day at 4 pm (time is chosen based on the diurnal variation of the water level; water level is highest in the evening and lowest in the morning –so in the afternoon water level is close to average). 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.

Equipment to be used for water sampling

- Waders
- 2 empty clean plastic bottles (500 ml) (labelled **S**ediment and **C**hemistry, respectively)
- Depth integrating sampler (US DH-48)
- Conductivity/temperature meter (WTW 341)
- Camera
- Field chart “River water”/Notebook

Procedure in the river

1. Walk/wade into the river along the river crossing rope to about 50 cms water depth. Safety first. If the river is very turbulent or if there is ice on the river botton, then sampling from the river bank/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 in order to prevent degassing.

3. Place the 500 ml **S-**bottle in the US DH-48 depth integrating device. Pull back the rear part of the device and place the bottle as shown in figure 7.13

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 up and down through the water profile until the bottle is full (c. 500 ml).

Figure 6.15 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).

5. 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)

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

7. Bring samples to the lab at the station

Figure 6.16 In situ measurement of conductivity and temperature in the river water (left). Ice formation on the river water (right)

Procedure in the lab

1. The S-sample for suspended sediment is left in the fridge and later (when more samples are collected) filtered according to the procedure given in section 7.5. Label the bottle with date and time or if you use a numbering system on the bottles –make sure you keep track on which bottle is collected when.

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

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.

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 in the field chart. 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. 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 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. Dirty and non-aqueous samples need more frequent calibrations. Old electrodes need more frequent calibrations. 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 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 ion rich 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 HCl. If alkalinity is not measured the same day as the sample has been taken, then store the sample in the fridge.

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 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. Tap to make sure you have no bubbles and adjust the amount to exact 2 ml (the max amount that this dispenser can hold) Notice: To avoid contamination of the HCl never fill the dispenser direct 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 until pH in the sample solution drops to pH 4.5.

7. In well buffered water samples, a 0.05 or 0.1 M HCl may be used instead of 0.01 M HCl. Notice: If another concentration is used, make sure that the dispenser is rinsed well in between.

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

9. Calculation of alkalinity: Alkalinity (mmol/L) = ((added HCl (ml) * concentration of HCl (mol/L))/ volume of sample (ml))*1000.

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). Filtering of samples should take place within 36 hours of collection.

Equipment to be used

- Magnetic filter funnel (for 47 mm filter)
- Magnetic filter cup
- 500 ml Erlenmeyer shaped filter flask
- Whatman GF/F filters. Glass fibre filters. Retention diameter 0.7 microm. 47 mm in diameter.
- Vacuum pump (Millipore).
- 1x 50 ml bottle/vial with label “RE_DD-MM-YYYY-HH”
- 1x 20 ml bottle/vial with label “RE_DD-MM-YYYY-HH”

Figure 7.3. Equipment for filtering of water samples. Vacuum pump -the right side is for suction and the left side for pressure. Always make sure that there is a filter attached in front of the suction (left). Magnetic filter funnel and filter cup and 500 ml Erlenmeyer shaped filter flask (middle). Final set-up, filter bottle attached to the vacuum pump (right)

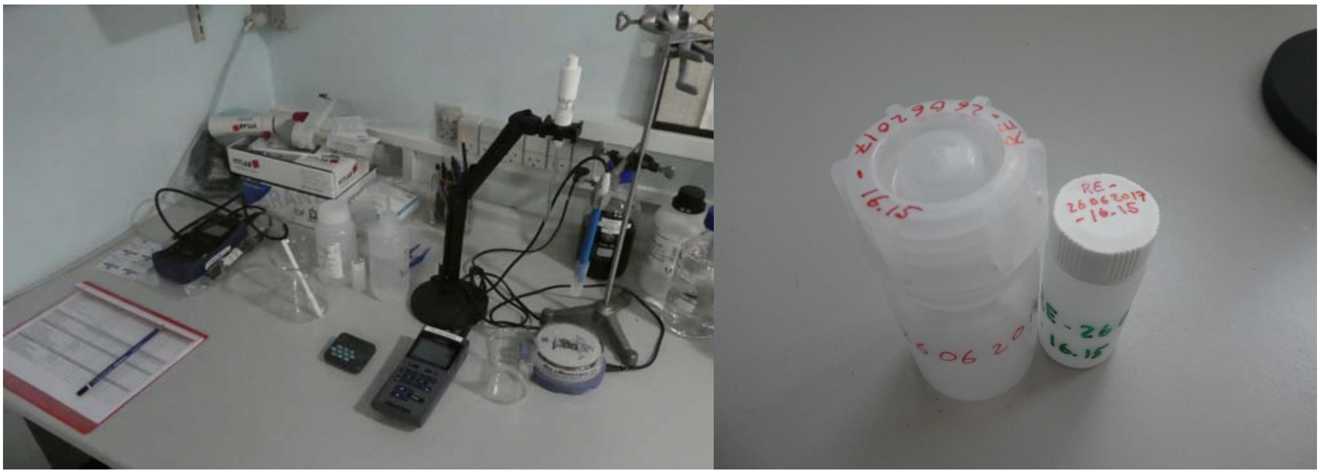


Figure 7.4 The GeoBasis corner in the Lab (left). Sub samples, 50 ml to IGN and 20 ml to BIO. Make sure they are labeled in a permanent way and labeled both on the side and on the lid (right).

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) (Soil water is labelled: SW DDMMYYYY_XXcm). Label both the bottle and the lid with a permanent marker.

2. All parts of the filter assembly must be thoroughly rinsed with de-ionized water. Rinse between samples and use a new filter for every sample.

3. Install the magnetic filter funnel on the glass bottle. Place a GF/F filter on the funnel and finally place the magnetic cup on top

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

5. Pour approximately 50 ml water in the cup and switch on the pump. When the water is filtered switch off the pump and de-mount the filter funnel. Use these first captured milliliters of filtered water to rinse the 500 ml glass bottle. After shaking vigorously, discard the water.

6. Re-mount the filter funnel on the glass bottle and pour another 50 ml in the cup. Use the filtered water to rinse the two collection bottles and caps. Fill the bottles half –add the lid -shake vigorously- discard the water

7. Pour 100 ml into the cup. Switch on the pump. Remove the filter funnel when the water is filtered and pour the water from the 500 ml glass bottle into the two collection bottles. Since the 20 ml vial are stored in the freezer it should only be 4/5 full to leave room for expansion. The 50 ml bottle is completely filled.

8. Place the 20 ml sample in a storage box labeled: GeoBasis, Water samples, YYYY in the freezer

9. Place the 50 ml bottle in a box labeled GeoBasis/Water samples/ YYYY in the fridge

10. At the end of the season or whenever GeoBasis staff is leaving the station bring samples to IGN, Copenhagen (Contact: Charlotte Sigsgaard). Remember a **Survey license** whenever samples are carried out of Greenland (Contact Charlotte)

7.5 Suspended sediment

The bottle labeled **S**ediment is for determination of suspended sediment. The filtration is carried out 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

- 500 ml sample bottle labeled **S** for sediment
- Magnetic filter funnel (for 47 mm filter) + red plast cork
- Magnetic filter cup
- Whatman GF/F filters. Glass fibre filters. Retention diameter 0.7 microm. 47 mm in diameter.
- Filtering flask with plastic hose connection and socket (3L).
- Vacuum pump
- Spray bottle with filtered water
- Tin foil
- Plastic cover for coins to store the filters in after they have been dried
- Field chart “River water”
- Analytical scale
- Scale (up to 1 kg)

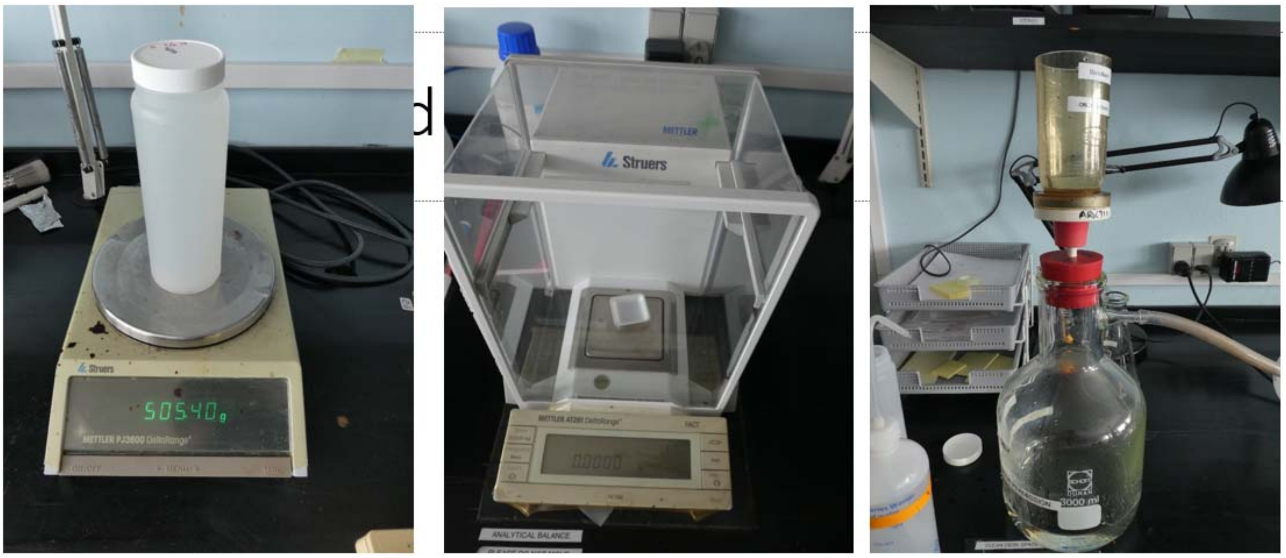


Figure 7.5 Weigh the bottle full and empty (left). Analytical scale and plastic tray is used when the filter is weighed (middle). Set-up for filtering using the 3 L bottle (right).

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 plast cork that fits the 3 L glass filter flask

3. Carefully place a dry GF/F filter on the analytical scale (use small plast weighing boat –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 it will close when vacuum is applied) and make sure there is a filter in front of the intake to the pump (the pump is damaged if water enters)

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 will be clocked. Just remember to weigh all dry filters and note the weight in the field chart.

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 since it is only the sediment that are used

8. Also use the spray bottle to make sure that all sediment grains are washed down 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 approach 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 then move the tin foil tray with filters into the plast 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 100°C and let it dry for at least 3-4 hours (until stable weight)

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 plast box (left). Weigh filter on the analytical scale

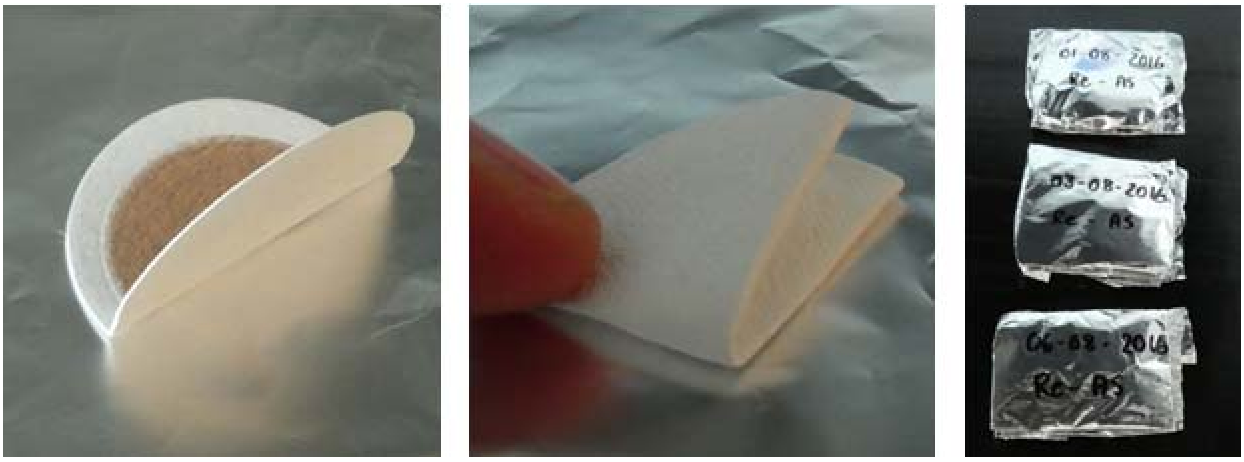


Figure 7.7 The dry filter is fold half and again into quarter. Store in tin foil and save in plast cover for coins

- Carefully, fold the filter on the middle and one more time. Take a 10x10 cm piece of tin foil. Wrap the tin foil around the folded filter. Make sure it is wrapped so no sediment can be lost and so that it is easy to unwrap. Place the small tin foil package in a small zip lock bag with label "Re_DD-MM-YYYY-HH". Save the filters in the plast sheets for coins and store at room temperature

- At the end of the season filters are brought 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 (DiskoBasis/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 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

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

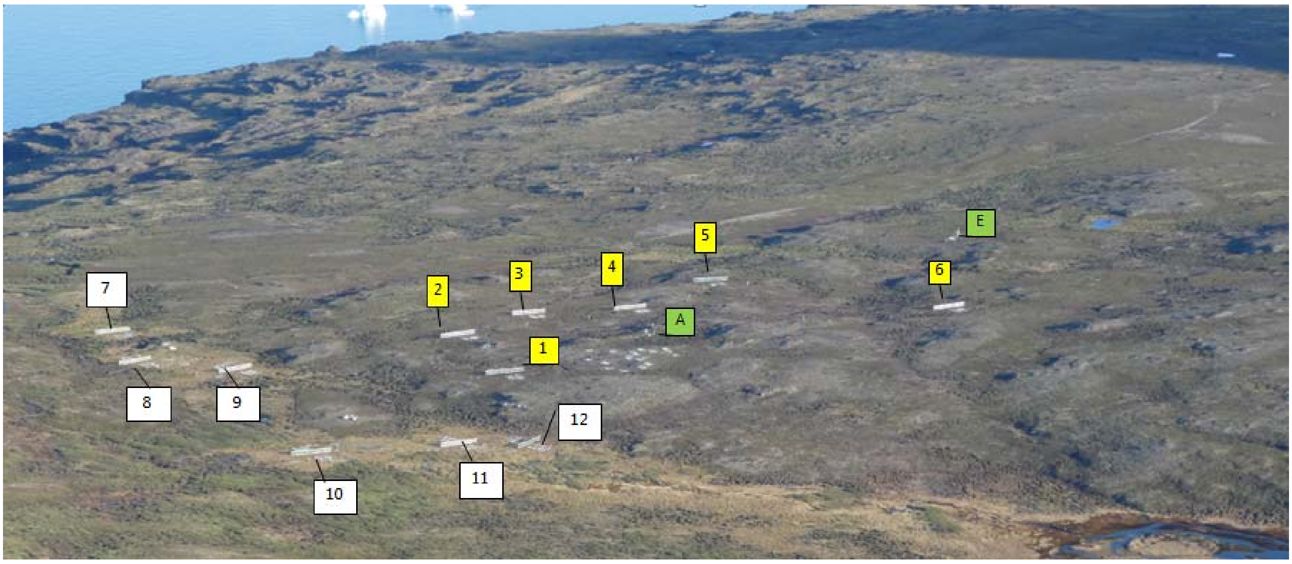


Figure 8.1 CENPERM experimental site in Blæsedalen. 1-6 Snowfences DRY, 7-12 Snowfences WET, A=AWS3, E=EC2. The photo is taken from Skarvefjeld looking SW.

8.1 NDVI monitoring

Automatic measurements/calculations of NDVI is 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 SKYE sensors on AWS3. PAR sensor and RED and NIR sensor

8.1.1 Manual NDVI monitoring

Next to all snow fences there are plots where plant phenology is studied. At 6 out of 12 sites there are cameras installed for automatic photo monitoring and the rest of the sites are similar plots but without camera

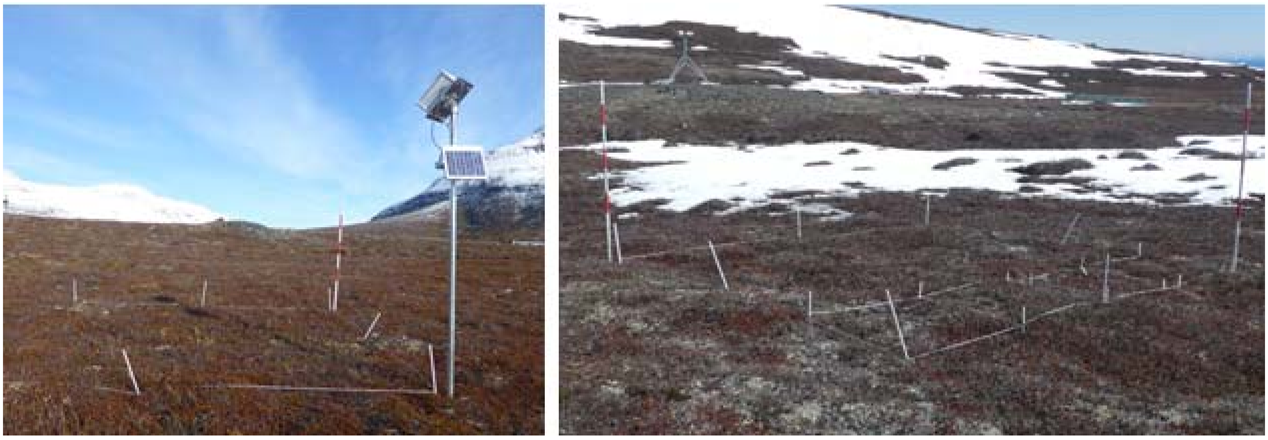


Figure 8.3 Set-up in one of the Phenology plots with camera (left) and without camera (right)

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). Below is the position of the SE corner of each plot.

Blok 1	Phenologiplot SØ-hjørne	69.26599	53.46528
Blok 2	Phenologiplot SØ-hjørne	69.26525	53.46540
Blok 3	Phenologiplot SØ-hjørne	69.26496	53.46642
Blok 4	Phenologiplot SØ-hjørne	69.26500	53.46750
Blok 5	Phenologiplot SØ-hjørne	69.26453	53.46882
Blok 6	Phenologiplot SØ-hjørne		
Blok 7	Phenologiplot SØ-hjørne	69.26469	53.46231
Blok 8	Phenologiplot SØ-hjørne	69.26529	53.46228
Blok 9	Phenologiplot SØ-hjørne	69.26551	53.46310
Blok 10	Phenologiplot SØ-hjørne	69.26677	53.46305
Blok 11	Phenologiplot SØ-hjørne	69.26673	53.46432
Blok 12	Phenologiplot SØ-hjørne	69.26674	53.46490

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. Never walk inside the plot.

2. The display meter switch on when the sensor is attached (plug in) and switch off when the sensor is removed. There is a button on the right side where it is possible to switch between RED and Far RED (see explanation on the back of the meter display). The button on the left 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 Manual captured photo of the vegetation plot (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. Place yourself so you do not shade. Also be aware of the shade from the camera set-up.

5. Read RED and FarRED and note right after (it is far easiest to be two person so one can write). Make three measurements. If out of range toggle the switch on the left side.

6. Move to the SW corner and repeat the measurement (3 replicates). Then to NW and NE.

7. When measurements have been performed from all 4 corners 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 60-70 cm above surface (left). Set-up in the WET area (right)

8.1.2 Automatic Greenness/NDVI monitoring

Photos from the automatic cameras can also be used for estimation of NDVI –variation in vegetation greenness. Since 2012 daily photos have been captured at Østerlien (section 4.2) and in the summer 2014, 6 new cameras were installed at the Snowfence site in Blæsedalen (experimental site by CENPERM). The 6 cameraes in Blæsedalen are located at some non-manipulated control plots next to the snow fences.

Location

Three cameras are located in the dry area just north of Block 3, 4 and 5 and three cameras are located in the wet area next to plot 8, 9 and 10.

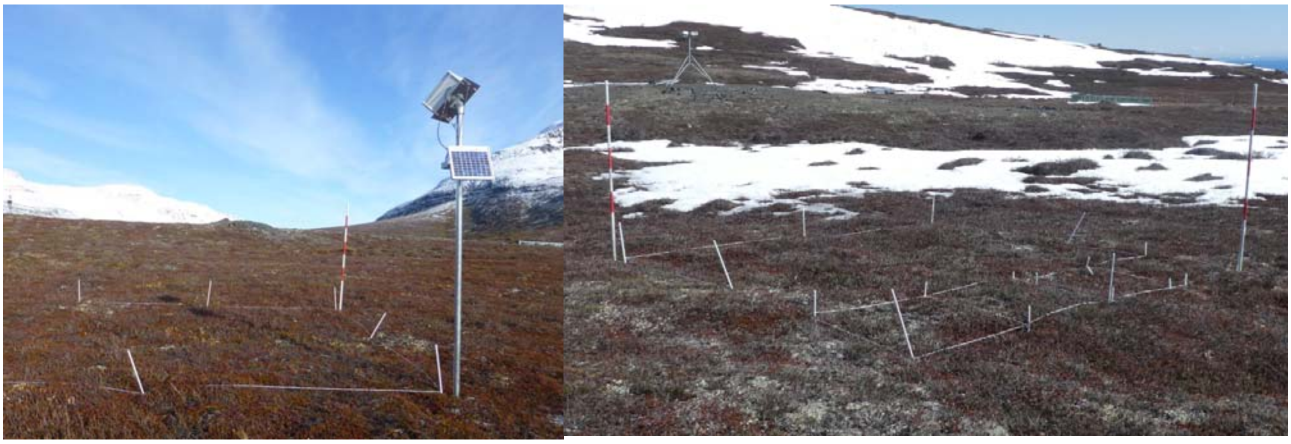


Figure 8.6 NDVI-3 in the dry snow fence area (left) NDVI-9 in the wet snowfence area (right)

Cameraes are mounted in a water proof box on a 2 m pole. The camera is looking down at the vegetation from a steep angle. Photos are captured at 9, 12 and 15. Photos are stored on a 16 GB SD card.

Frequency

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

Procedure

Offloading camera -see procedure in section 3.1.1

Camera settings –see section 3.1.2

NDVI målinger i Phenologiplots ved siden af Snehegnsblokkene i Blæsedalen

- NDVI måles med DiskoBasis NDVI måler (sort kuffert). NDVI måleren tændes ved at sætte stik fra sensoren i og slukkes ved at tage stik ud (vær forsigtig med at rykke I stikket!!). Vær opmærksom på ikke at få snavs på sensoren!!
- Der er 2 knapper på siden af måleren. Den til venstre gør det muligt at aflæse RED/Far RED/Ratio
- Den højre knap bruges til at indstille hvor mange decimaler man kan få med (vi ønsker så detaljeret som muligt)
- Der måles ikke i regnvejr, eller hvis vegetationen er våd
- Der måles ved siden af alle 12 blokke. I Blok 8, 9, 10 og 3, 4, 5 er der monteret phenologikamera, mens der ikke er I de øvrige.
- NDVI måleren rækkes ind fra hvert hjørne I feltet –undgå at lave skygge. Holdes ca 1 meter over vegetationen (tjek at måler peger lige ned). Lav 3 replikater fra hvert hjørne, hvor der aflæses RED og Far RED og Ratio. Det er en fordel at have en til at skrive/notere.
- Tag et billede udover feltet fra det SØ hjørne. Tages skrått ned over feltet. Lidt ligesom de fastmonterede kameraer gør. Tag gerne flere for at dække hele feltet

9 Precipitation

Liquid precipitation are measured/registered at the automatic weater stations AWS-1 and AWS3 and AWS4 by tipping bucket precipitation sensors. This means that only 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 station on Teleøen (Figure 1.1). Here precipitation is measured in heated models with screens to get a better estimate of the solid precipitation as well.

9.1 Automatic registration

Figure 9.1 Tipping bucket at AWS1 (left), test set-up at AWS3 (middle), Tipping bucket at AWS4 (right)

9.2 Precipitation bulk sampling

Precipitation is being 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 (Per Ambus, GNIP) where the total bulk precipitation is collected every month. Subsambles are later analyzed for isotopic composition. If there is more precipitation than needed by this project (60 ml), GeoBasis collects subsamples for chemical analysis.

Figure 9.2 Cummulative integrated sampler

Location

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

Frequency

Precipitation is collected every month (May, June, July, August, September)

Procedure in the field

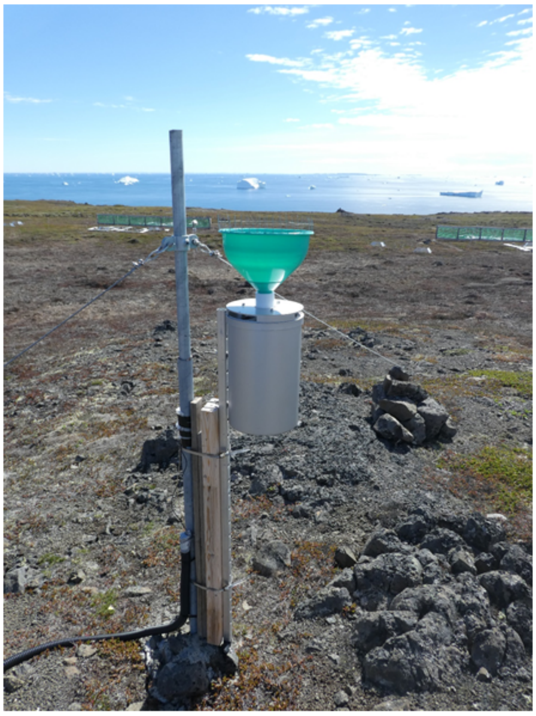
1. Bring out an extra 2 L bottle with green lid (stored in the Basis-room and labelled precipitation). Ensure the bottle is rinsed with deionized water

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. Attach/mount the new bottle inside the cover. Ensure that the tube from the sampler enters the bottle

5. Bring the precipitation to the lab at Arctic Station



Nedbørsopsamler I Blæsedalen (Per Ambus og GeoBasis)

- Nedbør fra juni måned indsamles den 1. juli. Medbring ny rengjort flaske skyllet i ionbyttet vand (2 liters flaske med grønt låg)
- Skru den flaske ud, som sidder i regnopsamleren og sæt låg på (fra den nye rengjorte flaske der er med ud)
- Monter den nye flaske (tjek at slange kommer ned I flasken)
- Kig I filteret foroven om der ligger noget snavs eller debris
- Ved hjemkomst vejes flaske med indhold, samt tom flaske, så man får vægten af vand (notér)
- Indhold hældes på flasker (star på hylde I GeoBasis rum I en kasse hvor der står Per Ambus på)
- Flasken med nedbør opbevares mørkt og ved køleskabstemperatur

Jeg skal lige høre hvor meget Per skal bruge. Hvis der er noget tilovers efter det, måles ledningsevne, og der filtreres en prøve gennem GF/F filter til en 20 ml flaske, som fryses og mærkes: Precip AS_DDMMYYYY (dato for indsamling)

Er der yderligere prøve tilbage måles pH og alkalinitet på en ikke filtreret prøve

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 and lid whenever it is empty

2. Pour 60 ml sample into the 60 ml bottle and store dark and cold (refrigerator)

3. If there is enough water (>60 ml) proceed in the following order

4. Measure conductivity (see procedure in section 7.1)

5. If there is more than 100 ml left, then pour a 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)

6. If there is less than 80 ml, then filter the water (follow section 7.4) and take subsamples of the filtered water into a 2x20 ml vials (labelled Precip: DD-MM-YYYY). Leave space for expansion due to freezing (fill only 4/5)

Appendix

APPENDIX 1 Installations

AWS-2_Østerlien: Mux (Datalogger CR1000 SN: E9412) — Position : 69°15'12.558" N, 53°30'50.863" W, 25 m asl

Log interv	Scan	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Elevation	Installed
30 min	10 min	Soil surface temperature	°C	Temperature sensor P1	100K6A1A		BetaTherm	0 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-10 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-20 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-30 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-40 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-50 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-60 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-70 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-80 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-90 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-100 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-110 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-120 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-130 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-140 cm	August 2012
30 min	10 min	Soil temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	-150 cm	August 2012
30 min	10 min	Soil surface temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	0 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	10 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	20 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	30 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	40 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	50 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	60 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	70 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	80 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	90 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	100 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	110 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	120 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	130 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	140 cm	August 2012
30 min	10 min	Air/snow temperature	°C	Soil temperature probe P1	100K6A1A		BetaTherm	150 cm	August 2012
30 min	10 min	Soil surface temperature	°C	Soil temperature probe	pt 107		Campbell Scientific	0 cm	August 2012
30 min	10 min	Soil surface temperature	°C	Soil temperature probe	pt 107		Campbell Scientific	0 cm	August 2012
30 min	10 min	Soil surface temperature	°C	Soil temperature probe P3	?	?	?	0 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-10 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-20 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-30 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-40 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-50 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-60 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-70 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-80 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-90 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-100 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-110 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-120 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-130 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-140 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P3	?	?	?	-150 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-5 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-10 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-20 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-30 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-50 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-100 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-150 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-200 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-250 cm	July 2013
30 min	10 min	Soil temperature	°C	Soil temperature probe P2	?	?	?	-350 cm	July 2013

AWS-2_Østerlien: Met (Datalogger CR1000 SN: E9412) — Position : 69°15'12.558" N, 53°30'50.863" W, 25 m asl

Log interv	Scan	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Elevation	Installed
30 min	30 sek	Battery minimum Voltage	Volts						August 2012
30 min	30 sek	Reference temperature	°C						August 2012
30 min	30 sek	Snow depth	m	Sonic ranging sensor	SR50A	S/N 4185	Campbell Scientific	282 cm	August 2012
30 min	30 sek	Air temperature	°C	Temperature and humidity sensor	CS215		Campbell Scientific	308 cm	August 2012
30 min	30 sek	Relative humidity	%	Temperature and humidity sensor	CS215		Campbell Scientific	308 cm	August 2012
30 min	30 sek	Air pressure	mbar	Air pressure sensor	CS100	4953201	Campbell Scientific	250 cm	August 2012
30 min	30 sek	Wind speed_max	m/s	Anemometer	A100R	5501	Campbell Scientific	338 cm	August 2012
30 min	30 sek	Wind speed_avg	m/s	Anemometer	A100R	6501	Campbell Scientific	338 cm	August 2012
30 min	30 sek	Wind direction_avg (geographic north)	°	Windvane	W200P		Campbell Scientific	338 cm	August 2012
30 min	30 sek	Wind speed	m/s	Anemometer	A100R		Campbell Scientific	338 cm	August 2012
30 min	30 sek	Short wave radiation_up	W/m2	Net radiometer	CNR4		Kipp & Zonen or Campbell	311 cm	August 2012
30 min	30 sek	Short wave radiation_down	W/m2	Net radiometer	CNR4		Kipp & Zonen or Campbell	311 cm	August 2012
30 min	30 sek	Long wave radiation_up	W/m2	Net radiometer	CNR4		Kipp & Zonen or Campbell	311 cm	August 2012
30 min	30 sek	Long wave radiation_down	W/m2	Net radiometer	CNR4		Kipp & Zonen or Campbell	311 cm	August 2012
30 min	30 sek	Netto short wave radiation	W/m2	Net radiometer	CNR4		Kipp & Zonen or Campbell	311 cm	August 2012
30 min	30 sek	Netto long wave radiation	W/m2	Net radiometer	CNR4		Kipp & Zonen or Campbell	311 cm	August 2012
30 min	30 sek	Netto radiation	W/m2	Net radiometer	CNR4		Kipp & Zonen or Campbell	311 cm	August 2012
30 min	30 sek	Albedo		Calculated					August 2012
30 min	30 sek	Instrument temperature	Kelvin	Net radiometer	CNR4		Kipp & Zonen or Campbell		August 2012
30 min	30 sek	Skye temperature	°C	Net radiometer	CNR4		Kipp & Zonen or Campbell		August 2012
30 min	30 sek	Ground temperature	°C	Net radiometer	CNR4		Kipp & Zonen or Campbell		August 2012
30 min	30 sek	RED	µmol/m2/	Skye radiation sensor	SKR 1800D	LT 40735/LT40734	SKYE	311 cm	August 2012
30 min	30 sek	NIR	µmol/m2/	Skye radiation sensor	SKR 1800D	LT 40735/LT40734	SKYE	311 cm	August 2012
30 min	30 sek	RVI -Relative Vegetation Index		Calculated					August 2012
30 min	30 sek	NDVI- Normalized Differential Vegetation Index		Calculated					August 2012
30 min	30 sek	Soil moisture	vol%	Soil moisture and temperature probe	SM300		Buch Holm, Delta-T Devices	-10 cm	August 2012
30 min	30 sek	Soil moisture	vol%	Soil moisture and temperature probe	SM300		Buch Holm, Delta-T Devices	-20 cm	August 2012
30 min	30 sek	Soil moisture	vol%	Soil moisture and temperature probe	SM300		Buch Holm, Delta-T Devices	-30 cm	August 2012
30 min	30 sek	Soil heat flux	mV	Hukseflux Soil heat flux plates	HFP01SC-10	002653	Campbell Scientific	-5 cm	August 2012
30 min	30 sek	Soil heat flux	mV	Hukseflux Soil heat flux plates	HFP01SC-10	002654	Campbell Scientific	-5 cm	August 2012
30 min		UV-B	W/cm2	Analog UV Biometer	501 DA		Solar light		June 2017
30 min		PAR	µmol	PAR Quantum sensor	SQ-110		SolData Instruments	311 cm	June 2017

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

Log interv	Scan	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Elevation	Installed
30 min	1 min	Battery voltage_min	Volts						July 2013
30 min	1 min	Battery voltage_max	Volts						July 2013
30 min	1 min	Lithium battery	Volt						July 2013
30 min	1 min	Reference temperature	°C						July 2013
30 min	1 min	Air temperature	°C	Temperature and humidity sensor	CS215		Campbell Scientific	220	July 2013
30 min	1 min	relative humidity	%	Temperature and humidity sensor	CS215		Campbell Scientific	220	July 2013
30 min	1 min	Wind speed_avg	m/s	Anemometer	A100R		Campbell Scientific	230	July 2013
30 min	1 min	Wind gust_max	m/s	Anemometer	A100R		Campbell Scientific	230	July 2013
30 min	1 min	Wind direction	Deg	Windvane	W200p		Campbell Scientific	230	July 2013
30 min	1 min	Wind direction std dev	Deg	Windvane	W200p		Campbell Scientific	230	July 2013

30 min	1 min	PAR_raw	mV	PAR sensor, Quantum sensor	SKP215	SNo.42581	Campbell Scientific	200	July 2013
30 min	1 min	RED_avg		Skye radiation sensor	SKR 1800	LT42809/LT42808	SKYE	200	July 2013
30 min	1 min	NIR_avg		Skye radiation sensor	SKR 1800	LT42809/LT42808	SKYE	200	July 2013
30 min	1 min	RVI_avg		Calculation					July 2013
30 min	1 min	NDVI_avg		Calculation					July 2013
30 min	10 min	Soil moisture	vol%	Soil moisture and temperature probe	SM300		Buch Holm	-5	July 2013
30 min	10 min	Soil moisture	vol%	Soil moisture and temperature probe	SM300		Buch Holm	-10	July 2013
30 min	10 min	Soil moisture	vol%	Soil moisture and temperature probe	SM300		Buch Holm	-20	July 2013
30 min	10 min	Soil moisture	vol%	Soil moisture and temperature probe	SM300		Buch Holm	-40	July 2013
30 min	1 min	Precipitation	mm	Precipitation gauge	ARG100		Campbell Scientific	60	August 2014
30 min	1 min	Precipitation	mm	Precipitation gauge	52202	8757	YOUNG	40	June 2017

AWS-4 Blæsedalen (Datalogger HOBO U30 10038120) — Position (dec degrees : 69,27282°N 053,45363° W, 240 m asl

Log interv	Scan	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Elevation	Installed
30 min		Water Content/Soil moisture	m3/m3	Soil probe	ECO5(S-SMC-M	1243594	Onset, HOBO		August 2015
30 min		Water Content/Soil Moisture	m3/m3	Soil probe	ECO5(S-SMC-M	1243595	Onset, HOBO		August 2015
30 min		Solar Radiation (Shortwave incoming)	W/m2	Pyranometer	S-Lib-XXXX	10005264	Onset, HOBO		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	10006407	Onset, HOBO		August 2015
30 min		Soil temperature	°C	Temperature sensor	S-TMB-XXXX	10006410	Onset, HOBO		August 2015
30 min		Rain	mm	Rain sensor	S-RGB-M002	10008694	Onset, HOBO		August 2015
30 min		Air temperature	°C	temperature and humidity sensor	S-THB-XXXX	10022301	Onset, HOBO		August 2015
30 min		Relatvie humidity	%	temperature and humidity sensor	S-THB-XXXX	10022301	Onset, HOBO		August 2015
30 min		Voltage	mV		91-U30-CVIA-X	10037763	Onset, HOBO		August 2015
30 min		Voltage	mV			10037763	Onset, HOBO		August 2015
30 min		Batt, V (LGR S/N: 10038120)	V				Onset, HOBO		August 2015

EC1_Gas flux Østerlien — Position : 69°15'12.558" N, 53°30'50.863" W, 25 m asl

Log interv	Scan	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Elevation	Installed
0,1 sek	0,1 sek	Horisontal windspeed, u	m/s	3D-Sonic anemometer	Gill HS-50	H000204	Gill Instruments, Lymington	205 cm	August 2012
0,1 sek	0,1 sek	Horisontal windspeed, v	m/s	3D-Sonic anemometer	Gill HS-50	H000204	Gill Instruments, Lymington	205 cm	August 2012
0,1 sek	0,1 sek	Vertical windspeed, w	m/s	3D-Sonic anemometer	Gill HS-50	H000204	Gill Instruments, Lymington	205 cm	August 2012
0,1 sek	0,1 sek	CO2-concentration	ppm	Gas Analyzer	Li-7200_HF10	72H-0318	LiCOR, Nebraska, USA	205 cm	August 2012
0,1 sek	0,1 sek	H2O-concentration	ppt	Gas Analyzer	Li-7200_HF10	72H-0318	LiCOR, Nebraska, USA	205 cm	August 2012
0,1 sek	0,1 sek	Instrument temperature inside	°C	Gas Analyzer	Li-7200_HF10	72H-0318	LiCOR, Nebraska, USA	213 cm	August 2012
0,1 sek	0,1 sek	Instrument temperature Outside	°C	Gas Analyzer	Li-7200_HF10	72H-0318	LiCOR, Nebraska, USA	213 cm	August 2012
0,1 sek	0,1 sek	Instrument pressure	kPa	Gas Analyzer	Li-7200_HF10	72H-0318	LiCOR, Nebraska, USA	213 cm	August 2012
				Analyzer Interface Box (October 2011)	Li-7550	AIU-0622	LiCOR, Nebraska, USA	120 cm	August 2012
				Analyzer flow module (October 2011)	Li-7200-101	FM1-0303	LiCOR, Nebraska, USA	120 cm	August 2012

HY-1 (436-2) Røde elv (YSI 6820-V2) — Position : 69°15'10.23''N, 53°29'57.57'' 5 m asl

Log interv	Scan	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Elevation	Installed
10 min		Water level	m	Multipar Water Quality Sonde -YSI 6820 V2-2			YSI		June 2013
10 min		pH		Multipar Water Quality Sonde -YSI 6820 V2-2	6589		YSI		June 2013
10 min		Specific conductivity	mS/cm	Multipar Water Quality Sonde -YSI 6820 V2-2	6560		YSI		June 2013
10 min		Water temperature	°C	Multipar Water Quality Sonde -YSI 6820 V2-2	6560		YSI		June 2013
10 min		Salinity	ppt	Multipar Water Quality Sonde -YSI 6820 V2-2			YSI		June 2013
10 min		Turbidity	NTU	Multipar Water Quality Sonde -YSI 6820 V2-2	6136		YSI		June 2013

AWS-1 Scientific leaders house (Datalogger Aanderaa) — Position : 69°15'11.0" N, 53°31'13.0", 25 m asl

Log interv	Scan	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Elevation	Installed
30 min		Air temperature	°C	Air temperature sensor	3455	2310	Aanderaa	950 cm	October 1990
30 min		Relative humidity	%	Relative humidity sensor	3445	1516	Aanderaa	950 cm	October 1990
30 min		Wind speed	m/s	Wind speed sensor	2740	3606	Aanderaa	950 cm	October 1990
30 min		Wind gust	m/s	Wind speed sensor	2740	3606	Aanderaa	950 cm	October 1990
30 min		Wind direction	°	Wind direction sensor	2750	1506	Aanderaa	950 cm	October 1990
30 min		Short wave radiation in	W/m2	Solar radiation sensor	2770	819	Aanderaa	200 cm	October 1990
30 min		Short wave radiation out	W/m2	Solar radiation sensor	2770	709	Aanderaa	200 cm	October 1990
30 min		Soil temperature -sediment	°C	Temperature sensor	3145	469	Aanderaa	-5 cm	October 1990
30 min		Soil temperature -sediment	°C	Temperature sensor	3145	470	Aanderaa	-60 cm	October 1990
30 min		Soil temperature -sediment	°C	Temperature sensor	3145	472	Aanderaa	-175 cm	October 1990
30 min		Rock temperature -top of bed rock	°C	Temperature sensor	3444	394	Aanderaa	-300 cm	October 1990
30 min		Precipitation	mm	Rain collector II			Davis	200 cm	October 1990

T1 (HOBO U23-003) — Position: 22W, 7686787mN, 402094mW, 125 masl

Log interv	Scan	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Elevation	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: 22W, 7688506mN, 404002mW, 830 masl

Log interv	Scan	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Elevation	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

T3 (HOBO U23-003) — Position: 22W, 7687165mN, 402989mW, 400 masl

Log interv	Scan	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Elevation	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

T4 (HOBO U23-003) — Position: 22W, 7684396 mN, 401220 mW, 1 masl

Log interv	Scan	Parameter	Unit	Instrumentation	Model	Serial No.	Manufacturer	Elevation	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

ID	Location	UTM	Northing	Easting	Elevation	Decimal degrees	
T4	Delta -Røde elv	22 W	7684396	401220	1	69.25127	53.49897
T1	Pjeturssons morraine	22W	7686787	402094	125	69.27300	53.47940
AWS-4	Skarvefjeld	22W	7686724	403108	240	69.27282	53.45363
T3	Skarvefjeld	22W	7687165	402989	399	69.27671	53.45710
T2	Top of Skarvefjeld	22W	7688506	404002	833	69.28909	53.43282
B6	NV-hjørne af Blok	22W			95	69.26551	53.47044
B5	NV-hjørne af Blok	22W			86	69.26453	53.46882
B4	NV-hjørne af Blok	22W			85	69.26500	53.46750
B3	NV-hjørne af Blok	22W				69.26496	53.46642
B2	NV-hjørne af Blok	22W			81	69.26525	53.46540
B1	NV-hjørne af Blok	22W			85	69.26599	53.46528
B12	NV-hjørne af Blok	22W				69.26674	53.46490
B11	NV-hjørne af Blok	22W			85	69.26673	53.46432
B10	NV-hjørne af Blok	22W			84	69.26677	53.46305
B9	NV-hjørne af Blok	22W			82	69.26551	53.46310
B8	NV-hjørne af Blok	22W			81	69.26529	53.46228
B7	NV-hjørne af Blok	22W			85	69.26469	53.46231
	Depot mellem Blok 1 og 2	22W	402612	7685921	90	69.26548	53.46528
Plot 1	Det NV hjørne af plot	22W			93	69.26600	53.46524
Plot 6	Det NV hjørne af plot	22W			92	69.26586	53.46521
Plot 11	Det NV hjørne af plot	22W			82	69.26525	53.46523
Plot 14	Det NV hjørne af plot	22W			89	69.26518	53.46521
Plot 17	Det NV hjørne af plot	22W			87	69.26497	53.46627
Plot 23	Det NV hjørne af plot	22W			85	69.26481	53.46624
Plot 28	Det NV hjørne af plot	22W			86	69.26500	53.46732
Plot 29	Det NV hjørne af plot	22W				69.26486	53.46719
Plot 34	Det NV hjørne af plot	22W				69.26450	53.46886
Plot 38	Det NV hjørne af plot	22W				69.26440	53.46857
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			118	69.27236	53.48127
T1	Pjeturssons morraine	22W	7686787	402094	125	69.27300	53.47940
AWS1	Videnskabelig leders hus	22W			30	69.25284	53.49933
AWS2	Østerlien	22W			25	69.25355	53.51414
AWS3	Blæsedalen	22W			90	69.265525	53.467324
AWS4	Skarvefjeld	22W	7686724	403108	240	69.27282	53.45363
EC-2	Eddymast Blæsedal	22W			85	69.26395	53.47202
	Multisonde Røde Elv	22W	7684665	401243			
	Anker østlig bred (tov)	22W					
	Anker vestlig bred (tov)	22W				69325369	53.49892

	Jordvandsplot Østerlien	22W				69.25349	53.51363
AS	Fotopunkt Arktisk Station	22W				69.25168	53.51456
SS	Fotopunkt Sorte Sand	22W				69.25073	53.51707
Blok 1	Phenologiplot SØ-hjørne				85	69.26599	53.46528
Blok 2	Phenologiplot SØ-hjørne				84	69.26525	53.46540
Blok 3	Phenologiplot SØ-hjørne				85	69.26496	53.46642
Blok 4	Phenologiplot SØ-hjørne				86	69.26500	53.46750
Blok 5	Phenologiplot SØ-hjørne				86	69.26453	53.46882
Blok 6	Phenologiplot SØ-hjørne						
Blok 7	Phenologiplot SØ-hjørne					69.26469	53.46231
Blok 8	Phenologiplot SØ-hjørne				81	69.26529	53.46228
Blok 9	Phenologiplot SØ-hjørne				82	69.26551	53.46310
Blok 10	Phenologiplot SØ-hjørne				84	69.26677	53.46305
Blok 11	Phenologiplot SØ-hjørne				85	69.26673	53.46432
Blok 12	Phenologiplot SØ-hjørne				85	69.26674	53.46490
	Kamera Østerlien						
	Kamera Lyngmark						
	Kamera Snow 6						
	Kamera Snow 4						
	Kamera Snow 2						
	Kamera Snow 9				87	69.26528	53.46374
	Kamera Snow 11						
Blok 1	Seasonal plot (center)						
Blok 2	Seasonal plot (center)						
Blok 3	Seasonal plot (center)						
Blok 4	Seasonal plot (center)						
Blok 5	Seasonal plot (center)						
Blok 6	Seasonal plot (center)						
Blok 7	Seasonal plot (center)						
Blok 8	Seasonal plot (center)						
Blok 9	Seasonal plot (center)						
Blok 10	Seasonal plot (center)						
Blok 11	Seasonal plot (center)						
Blok 12	Seasonal plot (center)						
SD1	Snow depth transect						
SD2	Snow depth transect						
SD3	Snow depth transect						
SD4	Snow depth transect						
SD5	Snow depth transect						
SD6	Snow depth transect						
SD7	Snow depth transect						

SD8	Snow depth transect						

Name: SD1
Latitude: 69.253303°
Longitude: -53.515307°

Name: SD2
Latitude: 69.254210°
Longitude: -53.515367°

Name: SD3
Latitude: 69.254176°
Longitude: -53.512821°

Name: SD4
Latitude: 69.253280°
Longitude: -53.512750°

Name: SD5
Latitude: 69.253161°
Longitude: -53.520396°

Name: SD6
Latitude: 69.253307°
Longitude: -53.521320°

Name: SD7
Latitude: 69.253474°
Longitude: -53.520219°

Name: SD8
Latitude: 69.252000°
Longitude: -53.515317°

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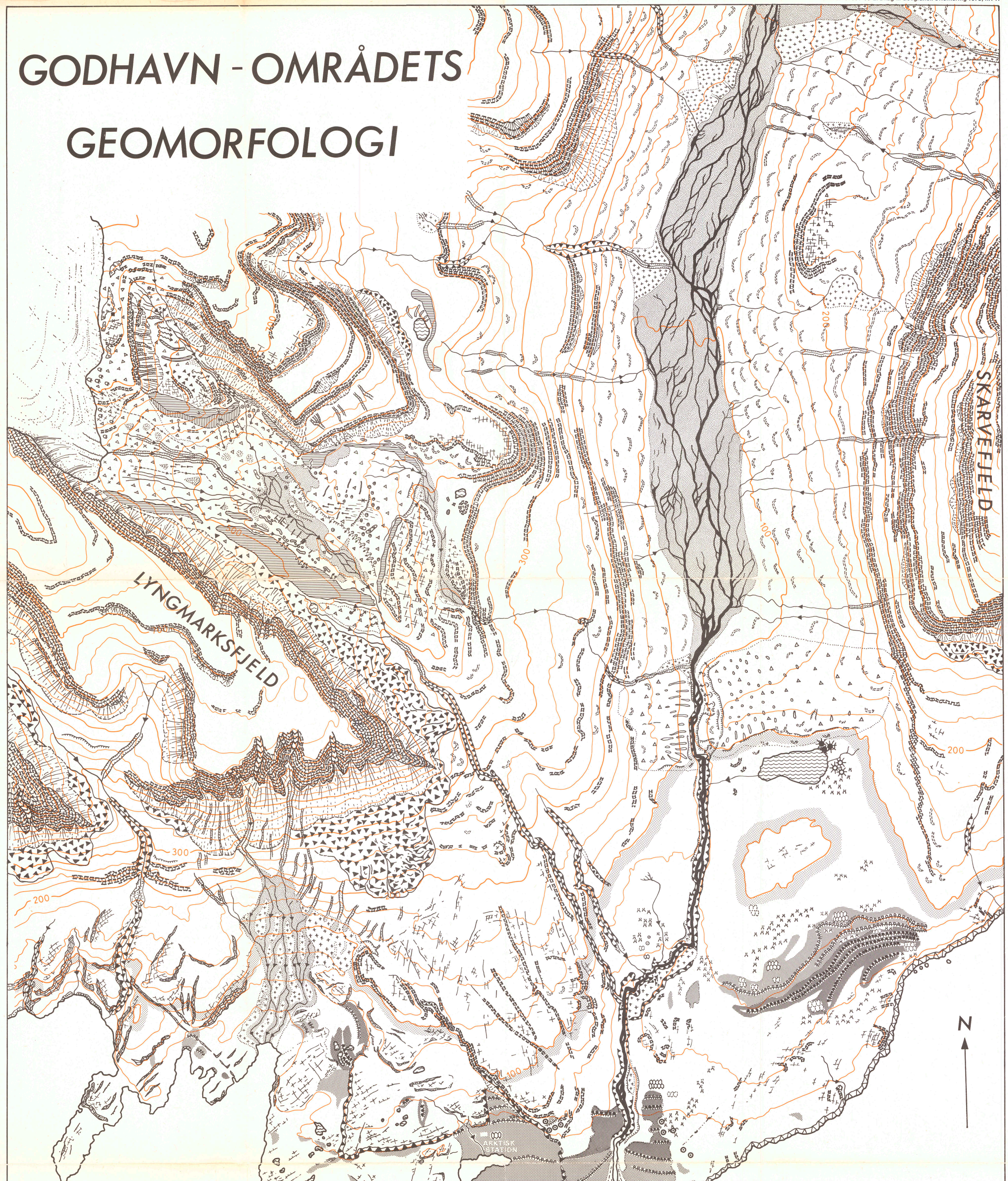
GODHAVN - OMRÅDETS GEOMORFOLOGI



Kortet er udarbejdet på grundlag af GI's kort: *Blæsedalen ved Godhavn* 1:20 000, forstørret til ca. 1:10 000. Med tilladelse fra Geodætisk Institut (A 521/77)

Gletscher

- Gletscherrand
- Foliation, mønster fremkaldt af isbevægelsen
- Vandløb på gletscheroverfladen
- Urenheder, smeltet frem eller ført ned på gletscheroverfladen
- Materiale skredet ned på gletscheroverfladen fra dalsiden
- Dødis, isoleret rest af gletscheris
- Dødis begravet under glaciale aflejringer

Isfrit terræn

- Sø
- Signaturgrænse
- Terrænknæk
- Stejl fjeldside med basaltbænke
- Stejl fjeldside udformet i gnejs
- Lavinebane (Chute) udformet i fjeldside
- Fjeldoverflade
- Fjeldoverflade med sporadisk dække af till
- Ismodelleret fjeldoverflade, rundklipper
- Fast fjeld blottet i små isolerede partier
- Skurestriber på isolerede blotninger af fast fjeld
- Aktive skredkegler (Talus) ved foden af fjeldvæg
- Inaktive skredkegler (Talus) ved foden af fjeldvæg
- Talusskråning m. markant taluskegle
- Blokmark
- Blokgletscher
- Till, materiale aflejret af gletscher
- Randmoræne
- Årsmoræner
- Større moræneryg, uspecificeret
- Små morænerygge, uspecificerede
- Fluted moræne
- Dødishuller
- Ås
- Smeltevandsaflejringer, aktive, uden specifik form
- Smeltevandsaflejringer, inaktive uden specifik form
- Smeltevandsaflejringer m. form
- Smeltevandskegle
- Flettet (braiderende) flodløb
- Enkelt vandløb
- Vandløb, nedskåret i løse aflejringer
- Vandløb, nedskåret i fast fjeld
- Mudderstrøm
- Indsynkninger ved smeltning af begravet dødis
- Trin fremkommet ved jordflydning (Solifluktion)
- Jordflydningslober
- Jordtuer
- Cirkler, sorterede
- Cirkler, usorterede
- Striber, usorterede
- Polygoner, sorterede
- Polygoner, usorterede
- Palser, udviklede
- Palser, embryonale
- Øvre marine grænse
- Kystklint i fast fjeld, aktiv
- Kystklint i fast fjeld, forladt
- Nuværende strandbred
- Delta
- Marine aflejringer, fortrinsvis grus og sten
- Marine aflejringer fortrinsvis sand
- Front af marin strandvoldsterrasse
- Front af marin terrasse
- Strandpiller