GeoBasis Manual

Guidelines and sampling procedures for the geographical monitoring program of Nuuk Basic in Kobbefjord

Version 11 – July 2020

NERO

NUUK ECOLOGICAL RESEARCH OPERATIONS

This edition of the GeoBasis Manual

Please note that this manual is continuously updated. The GeoBasis program is subject to changes and improvements and therefore, the manual is continuously under construction. New updates will be implemented in the next edition.

If you have questions or comments to this edition please contact:

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Acknowledgements

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Louise Holm Christensen, Karl Martin Iversen, Ken Hill, Marie Rasch, Daniel Rudd, Maria Burup, Sebastian Marker Westh, Stine Højlund Pedersen, Torben Røjle Christensen, Magnus Lund, Mikhail Mastepanov, Mikkel P. Tamstorf, Andreas Westergaard-Nielsen, Mathias Madsen, Charlotte Sigsgaard, Maria Rask Pedersen, Lena Ström, Frans-Jan Parmentier and Bo Elberling.

Birger Ulf Hansen and Kerstin Krøier Rasmussen

GeoBasis

1 Introduction

1.1. The GeoBasis program

GeoBasis is a subprogram of the environmental monitoring program Greenland Ecosystem Monitoring (GEM), which is funded by the Danish Energy Agency, Environmental Protection Agency and the Government of Greenland. The primary objective of the GeoBasis monitoring program in Kobbefjord is to establish baseline knowledge on the dynamics of fundamental physical parameters within a low Arctic environment. Low Arctic landscapes are extremely vulnerable to even small changes in physical conditions and therefore they are sensitive indicators for environmental and climate changes.
The GeoBasis program in Kobbefjord collects data of hydrological and terrestrial variables and parameters including:

- Flux monitoring; plot and landscape scale flux monitoring of CO_2, CH_4, H_2O and energy.
- Meteorology and energy balance; essential meteorological variables across various surface types and elevations.
- Soil properties; monitoring of key soil variables, including temperature, moisture, heat fluxes and soil water chemistry at different depths and surfaces.
- Snow, greenness and lake/fiord ice; monitored from automatic cameras
- River water electro chemistry
- Snow properties; including spatial and temporal variation in distribution, depth, temperature and density.

Collected data will be used to improve current model predictions for future changes in the ecosystem and to quantify the feedback mechanisms from the ecosystem to the climate change.
The GeoBasis monitoring in Kobbefjord was initiated in 2007 and based on the first year's experiences additional activities have been and will be incorporated in the program.

1.2. GeoBasis database

Data from the GeoBasis Nuuk monitoring program is freely available through the GEM database www.g-e-m.dk. Any questions according the GeoBasis Nuuk data can be addressed to Birger Ulf Hansen (buh@ign.ku.dk) or Kerstin Krøier Rasmussen (ker@asiaq.gl).

All GeoBasis data are public domain. However, 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.

All timestamps referred to in the database and in the daily diurnal are in West Greenlandic Winter Time (WGWT). Selected data from each field season is published in the 'GEM Annual Report Cards,
published by Aarhus University. Until 2016 data were published in the 'GEM Annual Report'.

1.3. Links

- Nuuk Basic: www.nuuk-basic.dk
- Annual Report Cards http://g-e-m.dk/gem-publications-and-reports/gem-annual-report-cards/
- Greenland Ecosystem Monitoring: www.g-e-m.dk
- Zackenberg Research Station (ZERO): www.zackenberg.dk
- INTERACT: www.eu-interact.org/

1.4. Field season/period

Nuuk Basic does not have a defined field season. The field frequency of visits is nevertheless determined by the accessibility to the station. Prior to the breakup of the fiord ice the station is only accessible by ski or snowmobile. The frequency of visits decreases with the arrival of the first snow in October, but the fiord does normally not close up before December. In the following table, the field season length of each year is shown:

Year	Start	DOY	End	DOY	Length (days)
2007	11-Jun	162	30-Oct	303	141
2008	24-Jun	176	17-Nov	322	146
2009	14-May	134	03-Nov	307	173
2010	03-May	123	13-Oct	286	163
2011	11-May	131	20-Oct	293	162
2012	15-May	136	08-Nov	313	177
2013	22-May	142	31-Oct	304	162
2014	27-May	147	14-Nov	318	171
2015	15-Jun	166	21-Oct	294	128
2016	27-Apr	118	21-Oct	295	177
2017	02-Jun	153	13-Oct	286	133
2018	04-Jun	155	21-Oct	294	139
2019	14-May	134	25-Oct	298	164

1.5. Getting there

The field site in Kobbefjord is accessed by boat. Greenland Institute of Natural Resources (GINR) has two boats (Aage V. Jensen II and Avataq) that are used for regular transportation to and from the area. Information on how to book the boats can be found on http://www.natur.gl/en/the-institute/booking-of-facilities/.
During the field season, Aage is booked for the NuukBasic team Monday/Wednesday/Friday during odd weeks and Tuesday/Thursday in even weeks as default.

The boat will normally sail from Bro H in Iggia at 8.30 and from Kobbefjord around 15.00, however the days and times are depending on weather, work load and other NuukBasic staff, so remember to keep in touch with GINR:
Katrine Raundrup: kara@natur.gl
Maia Olsen: maol@natur.gl
Booking: booking@natur.gl

1.6. Getting around in the area

In order to protect the area in Kobbefjord and to minimize the impact on vegetation near the research sites and plots, some rules must be respected. Please, study the site manual (**Appendix 11 Site Manual**) carefully for a description of the regulations in different zones of the valley. Staff from the monitoring program must be prepared to give an introduction to the nearest surroundings and a guided tour, when new people arrive at the station.

- Follow trails and paths if possible
- Use the boardwalks, when working in the fen
- Do not throw garbage of any kind, not even apple core
- Use the toilet in the hut
- Do not make changes on the vegetation and the soil

1.7. Safety

Always follow the safety instructions from the Nuuk Basic Research Station, when you work in the area. GeoBasis has two VHF radios (Channel 72) and share an Iridium satellite telephone with BioBasis (+881641482375). Riffles and first aid kit can be borrowed from the Research Station. GeoBasis has a signal pistol.

Other occupational risks are:

- *Weather*
  The weather can change very rapidly. Therefore, it is advisable to check the weather forecast and adapt the field activities to the weather.
- *Falling down*
  Probably the greatest risk, when working in Kobbefjord, is tripping or falling down when walking around in the area. Always take care and reevaluate a chosen route. Bring a VHF radio and a first aid kit with you.
- *Rock slides/loose rocks /rock avalanches*
  Look out for loose rocks. If you are two persons then spread out so that you don't push rocks down into each other. Some landscape elements are more prone to rock avalanches. Look out for terrain of fresh boulders.
- *Electric shock*
  The solar panels, battery bank and the 220V charge regulator can give electrical shock if short circuited. Be careful to turn off the current and check that all switches are off when working with cables and the power supply. The battery bank is always dangerous if tools short circuit. Double check (+) and (-) and color codes when working on the 12V supply. When working with the solar panels cover them with a jacket or similar, so they do not receive any or only limited power during work.
- *Sailing with boat*
  The boatman is responsible for person safety when onboard the boat. Wear a safety west.
- *Bear*
  In 2008 -2015 nine polar bears were sited around Nuuk, primarily in the spring. Therefore, there is a small risk of encountering a bear in Kobbefjord.

1.8. Weather and Ice

Many of the field activities are weather dependent and a part of planning the field work is to follow weather development: www.dmi.dk/dmi/byvejr_gl.htm?by=4250

To check the ice situation in the fiord use this website:
https://apps.sentinel-hub.com/sentinel-playground/

1.9. GeoBasis Nuuk Staff

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1.13. Daily Journal

We write a daily field journal to document the work we do. The field journal is a very important tool when the data is quality controlled. If there are some gabs or errors in data, it is important to see exactly what and when we have done some work at a station. The journal is also used when problems occur, and we want to solve a problem that might have been there before. So write a good and precise journal and remember to look for answers in the journals of the previous years, when you have problems.

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

- Personal in the fiord
- Details about work carried out and the time (WGWT)
- Weather report (temperature, clouds, precipitation, wind, fog)
- Condition of the Kobbefjord river (water level, snow/ice, algae)
- Snow cover and ice condition and distribution
- Voltage on power stations
- Special events

It is always a good idea to record relevant pictures in the journal!

1.14. Equipment

1.14.1. Hut

Inside the hut GeoBasis and BioBasis share most of the space and shelves. GeoBasis have:

- The shelves on the left side of the door
- Half of the shelves above the table
- 3 boxes under the table
- 2 drawers under the table under the window
- The inner right corner of the storage room under the hut

NB: Since 2020 some equipment might have been moved to the new storage hut

It is important that the GeoBasis equipment is always available and functioning; therefore under normal circumstances do not lend the equipment out to others, especially not the radios and safety equipment.

If you lend someone some GeoBasis equipment make sure to make agreement on:

- What it is used for
- When it will be back
- That they should replace it with new if something break

1.14.2. Asiaq

At Asiaq GeoBasis has equipment at three places:

- Office: Two bookcases
- Workshop: Tre shelves next to HKM shelves
- Kold lager: The space under the shelves in the inner corner next to the door.

1.14.3. The GeoBasis Field tablet

The field tablet has all necessary programs installed.
There are two ways to login to the tablet:

1) Login to Asiaq network (without any administrator permissions)
2) Login as local administrator (no access to network)

Login and passwords are found in the GeoBasis notebook.

Normally you should use the logon to the Asiaq network, but if you want to install a new program or change any setups, you might need administrator permissions.
The tablet has WiFi and connects to the network at Asiaq, but everything works more efficiently if you use the Ethernet cable for a direct connection to the network.

2. The Monitoring Area and the GeoBasis Stations

The Nuuk Basic catchment area is approximately 32 km^2 and located at the bottom of Kobbefjord/Kangerluarssunguaq (64°07' N, 51°21' W) approx. 20 km south-east of Nuuk. The area is characterised by three major valleys surrounded by steep hills reaching approx. 1300 m a.s.l.

The mean annual air temperature in the monitoring area is -0.1 °C (2008-2017). The warmest month is July (average temperature 10.6 °C) while the coldest month is March (average temperature -8.2 °C). The mean precipitation in Kobbefjord is around 800 mm and maximum snow depths vary strongly (between 0.3 and 1.3 at the ClimateBasis Station). The average mean, minimum and maximum air temperatures from the period 2008-2017 are seen in Figure 2.1

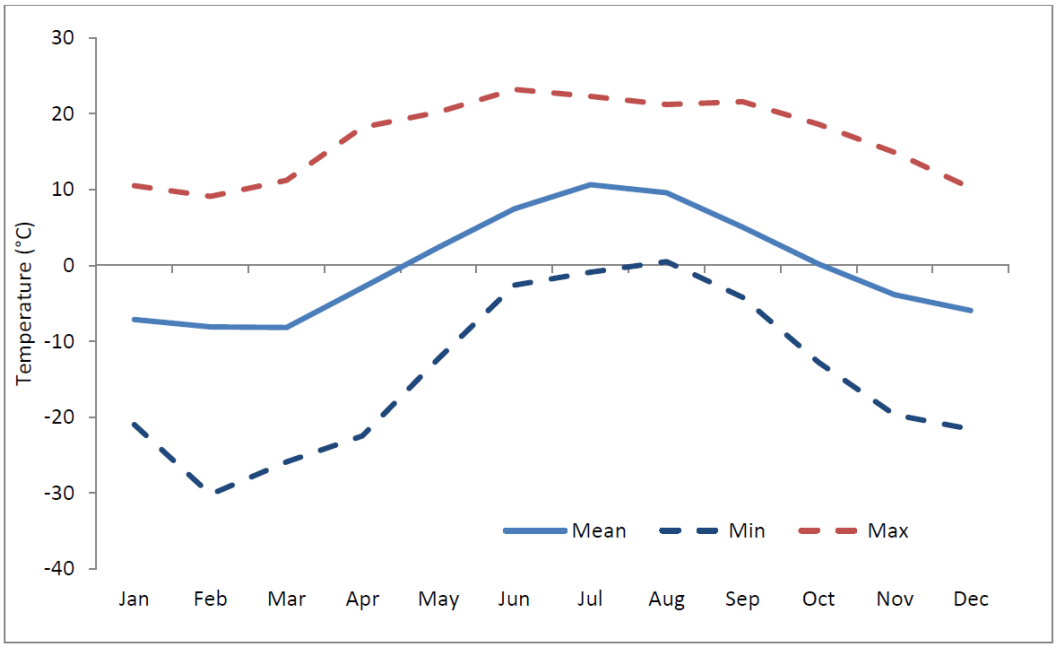


Figure 2.1 Air temperatures measured at the Climate stations (Asiaq) in Kobbefjord in the period 2008-2017.

The GeoBasis program has 18 monitoring stations at eight sites in Kobbefjord. A full overview of the stations, parameters and sensors can be found in **Appendix 1**. Furthermore, the stations can be seen in Figure 2.2 and the related coordinates are found in table 2.1. During the field season and the snow survey, additionally data is sampled manually. Apart from the flux monitoring stations and manual measurements, all stations measure all year round.

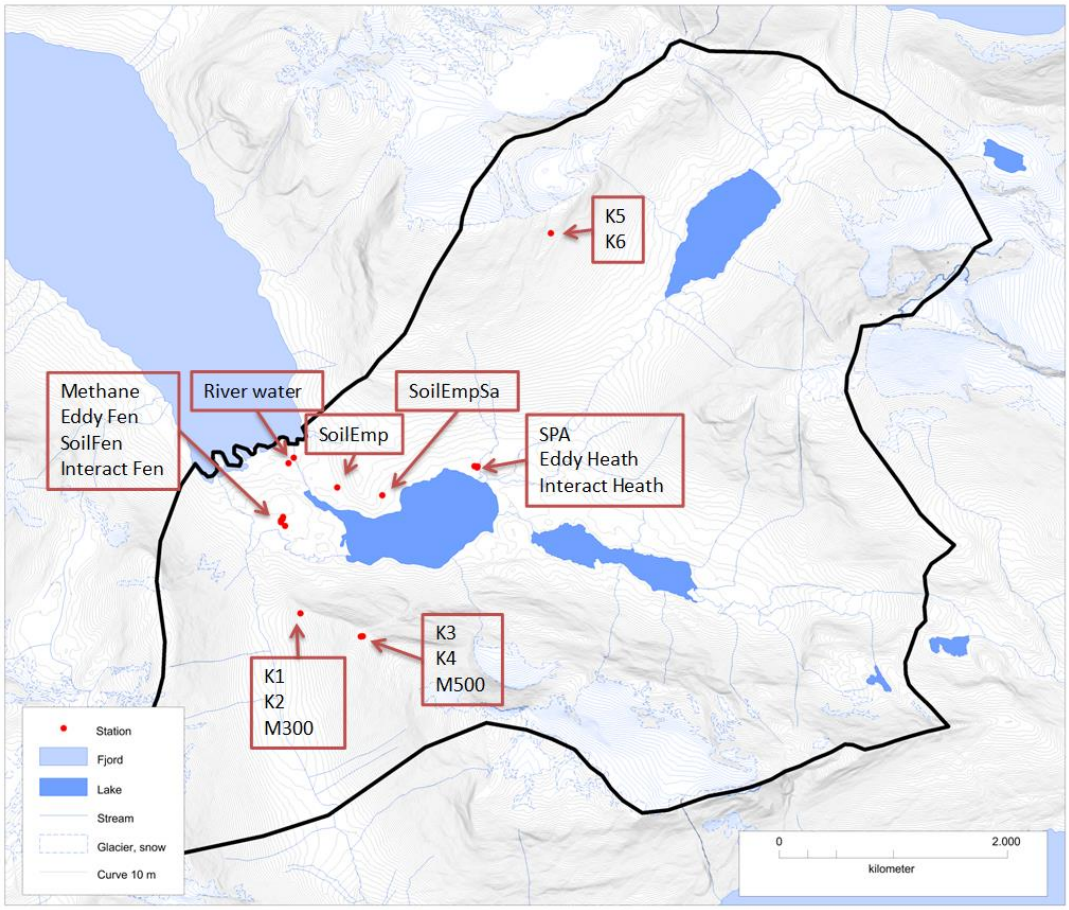


Figure 2.2 GeoBasis installations in Kobbefjord.

Table 2.1 List of the geographical coordinates of the GeoBasis installations in Kobbefjord, WGS 84.

Station	Station ID	UTM, 22 W		Lat-long, degree, min, sec		Elevation
		N	E	N	V	meter
K1		7110911.00	481363.67	64° 7'27.14"	51°22'57.83"	295
K2		7110849.33	481414.33	64° 7'25.15"	51°22'54.04"	307
K3		7110732.00	481883.00	64° 7'21.46"	51°22'19.31"	546
K4		7110739.75	481919.25	64° 7'21.69"	51°22'16.66"	533
K5		7113965.00	483153.00	64° 9'6.14"	51°20'46.73"	757
K6		7113965.00	483153.00	64° 9'6.14"	51°20'46.73"	757
M300	GB07	7110897.00	481375.00	64° 7'26.70"	51°22'56.94"	295
M500	GB01	7110716.67	481885.33	64° 7'20.95"	51°22'19.16"	548
SoilFen	GB03	7111631.44	481236.10	64° 7'50.39"	51°23'7.54"	40
SoilEmp	GB04	7111968.61	481691.05	64° 8'1.37"	51°22'34.04"	33
SoilEmpSa	GB05	7111955.70	482106.95	64° 8'1.04"	51°22'3.28"	40
Interact Fen	I5Nf	7111669.79	481197.29	64° 7'51.60"	51°23'10.45"	40
Interact Heath	I6Nh	7112138.33	482919.19	64° 8'7.07"	51°21'3.30"	26
Methan		7111690.52	481214.60	64° 7'52.28"	51°23'9.20"	40
Eddy Fen		7111655.02	481207.91	64° 7'51.15"	51°23'9.63"	40
Eddy Heath		7112130.64	482919.98	64° 8'6.81"	51°21'3.30"	26
SPA		7112103.35	482918.56	64° 8'5.94"	51°21'3.36"	25
River water		7112227.24	481301.53	64° 8'9.65"	51°23'3.00"	9
Power Fen		7112153.74	482380.02	64° 7'52.93"	51°23'9.13"	51
Power Heath		7112114.81	482921.25	64° 8'6.32"	51°21'3.12"	25
Hut		7112182.44	481264.11	64° 8'8.19"	51°23'5.72"	16

3. Snow, ice and greenness monitoring

3.1. Introduction

Snow and ice cover are important parameters for the ecosystems in Arctic. The distribution and timing of the snow and ice cover have an influence on the vegetation distribution and the length of the growing season, which again will affect the fluxes of greenhouse gasses such as carbon dioxide and methane. The snow conditions and vegetation distribution will also have a major effect on the thermal regime, the moisture content and the energy fluxes of the soil.

Six automatic cameras are taking pictures of valleys, lakes and fiord from three of the mountains surrounding the monitoring area. These cameras take pictures every day year-round. Furthermore, pictures of specific glaciers and snow patches seen from the valley are taken manually each year in mid-August. Pictures are used to validate the meteorological data from the monitoring stations, monitor special events like avalanches and storms and to determine growing seasons and the timing of ice on the lakes and fiord.

Data is not yet in the GEM database

3.2. Automatic camera monitoring, K1-K6

3.2.1. Introduction

Six automatic digital cameras are installed in Kobbefjord (K1-K6). The cameras are taking pictures all year and the purpose is primarily to monitor the vegetation greenness, snow cover, fjord ice, lake ice and glaciers.

In 2009 all camera sites except K2 were repositioned because snow built up around the cameras the two previous winters. All cameras are triggered once a day (at 13:00) all year, while K1 and K2 in periods take more pictures a day. An overview is given below in Table 5.1.

Table 3.1 Trigger times of automatic cameras

Camera	Trigger time	Period
K1 and K2, 300 m a.s.l	10:00	March-October
	13:00	All year
	16:00	March-October
K3 and K4, 500 m a.s.l	13:00	All year
K5 and K6, 800 m a.s.l	13:00	All year

3.2.2. Camera systems and history

System 1: 2GB Hp Photosmart E427 6.9mm camera that is controlled by a Time Guard timer (EL11). Powered by a 4V 10h Cyclon battery charged by a small solar panel

System 2: CameraBox invented by Bo Holm Rasmussen with a Canon EOS camera, triggerbox, two sets of batteries and 16 GB SD card. System 2 had a lot of problems.

System 3: Invented by Jens Gammeltoft with a Canon EOS camera, trigger box, Panasonic 3.4 Ampere battery, solar panels and 16 GB SD card. Trigger box controlled via the program: *cambox control.*

System 4: Invented by Andreas Westergaard with a Canon EOS camera, trigger box, Panasonic 3.4 battery, solar panels and 16 GB SD-card.

An overview of the history of the camera systems are given in Table 3.2

Table 3.2 History and systems of the automatic cameras

	System 1	System 2	System 3	System 4
K1	*2007-2011*	*2011-2013*	**2013-**	
K2	*2007-2012*	*2012-2013*	**2013-**	
K3	**2007-**			
K4	**2007-**			
K5	*2007-2014*		**2014-**	
K6	*2007-2015*			**2015-**

3.2.3. Frequency and Field Guide

The cameras in 300 and 500 meters (K1-K4) should be checked 2-4 times in the field season and occasionally during winter if possible. The cameras in 800 meters (K5 and K6) are less accessible and are visited once per field season and if possible more times. K5 and K6 are close to M1000 (former GeoBasis station, now Asiaq) and sometimes Asiaq staff has field trips to that station and the Qassianguit glacier with helicopter. With some luck, there will be room for a GeoBasis person on one of those trips.

A description of how to get to the cameras and a guide to the different stations are found in **Appendix 2**. Figures 3.1-3.6 are showing the six different camera set-ups and their systems. For each camera station an automatically captured picture is shown.

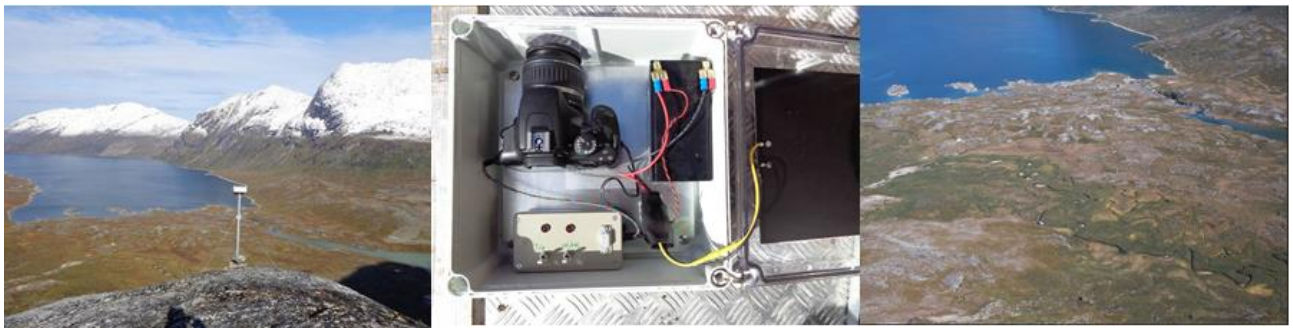


Figure 3.1 Figure 3.1 K1, 300 m.a.s.l. Pointing towards the fen. System 3.

Figure 3.2 K2, 300 m.a.s.l. Pointing towards South Valley. System 3.

Figure 3.3 K3, 500 m.a.s.l. Pointing toward the fiord. System 1.

Figure 3.4 K4 500 m.a.s.l. Pointing towards Badesø, the heath and Qassi Valley. System 1.

Figure 3.5 K5, 800 m.a.s.l. pointing towards Badesø and Langesø. System 3.

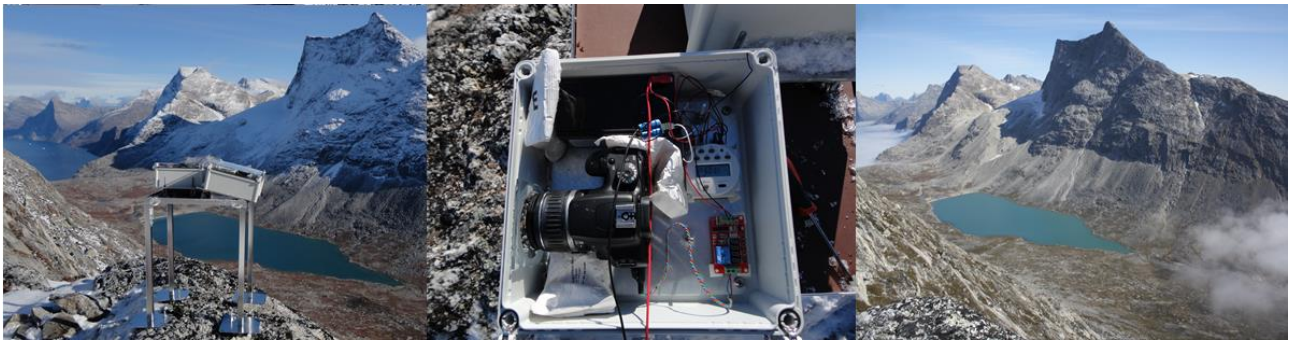


Figure 3.6 K6 800 m.a.s.l. pointing towards Qassi. System 4.

3.2.4. Data handling at the office

1. Check if all pictures are there
2. Check all pictures for sharpness and zoom
3. Copy pictures to their respective station folders at the office PC: *P:\B53_Nuuk_Basic\b53-06 GeoBasis\GeoBasis Stations\Cameras\KX_XXX*
4. Rename the pictures according to the description in **Appendix 2**.
5. The field charts are saved in the station folder at the office PC: *P:\B53_Nuuk_Basic\b53-06 GeoBasis\GeoBasis Stations\Cameras\Field charts*.
6. Normally Maia Olsen (GINR) will show up at Asiaq to get the pictures from the winter after the first visit to the cameras.
7. If anyone outside of Nuuk ask for the pictures put them at the ftp-server *nuukbasic (\\Asiaq01) (J:)* in a limited period (the pictures takes up a lot of space on the ftp server). Send an email with information on ftp address and login to the receiver.

3.2.5. Setting up a camera to system 3 and 4

These are the settings that the camera should have when it is installed in the field:

- Installed non-protected SD memory card with the card cover firmly closed
- Lens focus mode switch = AF (auto focus)
- Lens image stabilizer switch = OFF (if available on the lens)
- Power switch = ON
- Mode dial = P
- White balance = Auto (press 

next to display and choose auto)
- ISO = Auto (press 

next to on/off and choose auto)
- Metering mode = Evaluative metering (press )
- Quality = RAW (under MENU)
- Beep = OFF (under MENU)
- Review time = OFF (under MENU)
- Color space = sRGB (under MENU)
- Auto power off time = 30 sec (under MENU)
- Time and date = [same as Trigger Box] (under MENU)
- Flash control → Flash firing = Disable (under MENU)

Set the Mode dial to Landscape mode and use manual focus to adjust sharpness in the center of the image frame. Press the shutter half way down to allow the camera to find a suitable aperture (f-value). Set the Mode dial back to Av, and use the scroll wheel (in between the ISO selector and shutter) to select the same aperture as the camera suggested in Landscape mode. This maneuver results in an optimal sharpness for landscape imagery. The Av mode has automatic shutter speeds compensating for the fixed aperture.

3.2.6. Start up in spring

At the first visit after winter, change silica bags about 3 bags. If the enclosure during the season is not 100 percent dry, then change silica bags again. Otherwise, it is ok to change them only two times a year. Make sure the camera have the same position and zoom as it is supposed to.

3.2.7. Close down in fall

Make sure the camera system is OK, wires are tight, change silica bags, leave 3 bags for the winter; be sure water or snow cannot enter the enclosure. Apply silicone fat on the rubber sealing on the lid, the silicone that does not get hard, when drying. Make sure there is enough space on the memory card to log photos during winter.

3.3. Photos of glaciers and snow patches (August 11th)

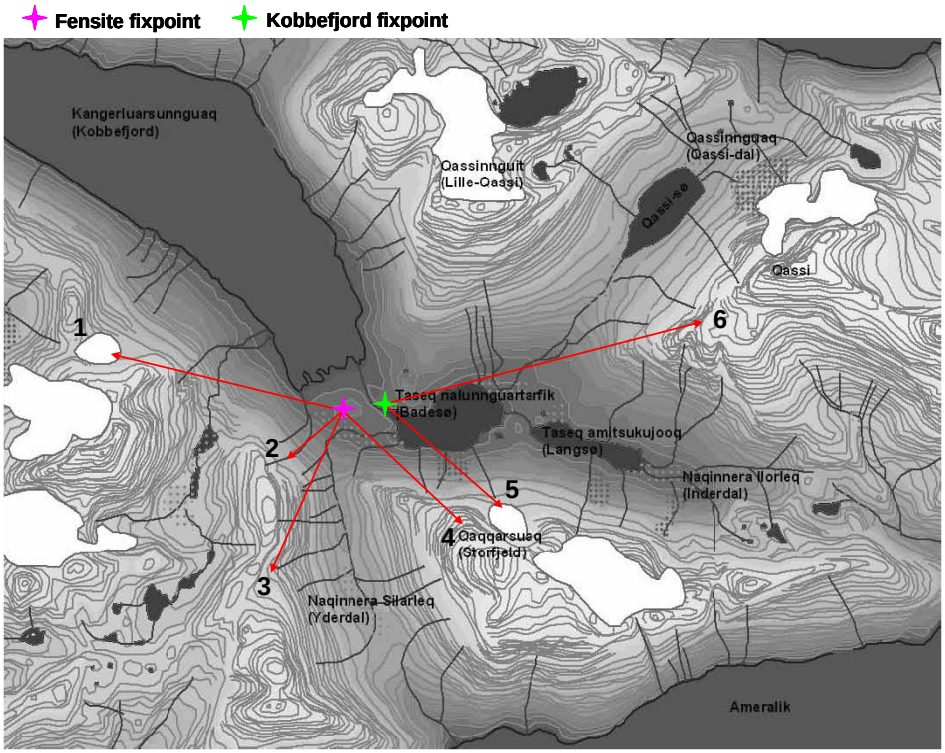


Figure 3.7 Overview of the glaciers and snow patches visible from the Fensite fix point and Kobbefjord fix point.

3.3.1. Introduction

Digital photos of the visible glaciers and snow patches of the monitoring area are taken manually from the Fensite fix point (bench mark) and Kobbefjord fix point as close as possible to the date August, 11th (in clear weather if possible). The photos are taken with the GeoBasis digital camera. Take more than one picture of each object. The two fix points are seen in Figures 3.8.

Figure 3.8 Kobbefjord fix point at the northern side of the river (left) and Fen fix point next to the Methane station (right).

Examples of the pictures are seen in Figure 3.9

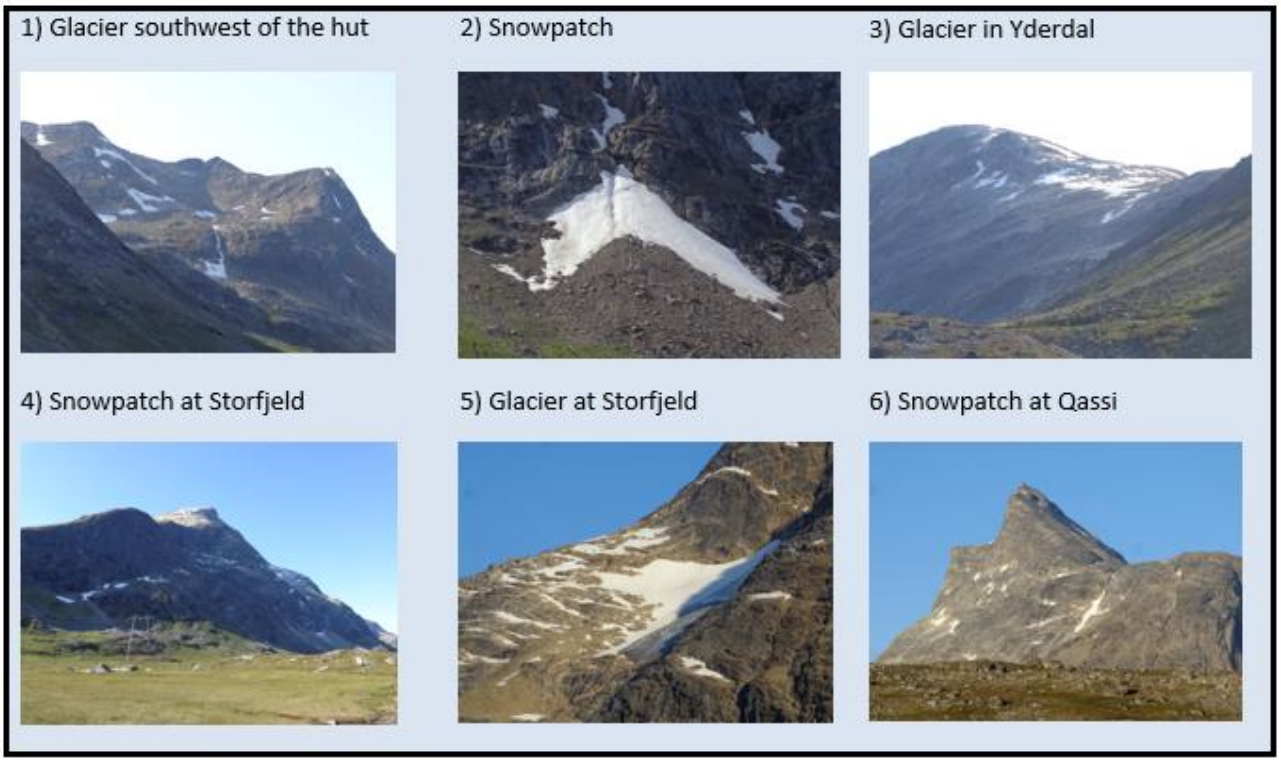


Figure 3.9 The three glaciers and three snow patches captured manually every year in August.

3.3.2. History

The photos have been taken since 2010.

3.3.3. Frequency

Once a year on August 11th. It can be necessary to take the pictures some days before or after due to bad weather or timing.

3.3.4. Data handling

The photos are uploaded at the office pc in the folders for each glacier or snow patch (1-6) (*P:\B53_Nuuk_Basic\b53-06 GeoBasis\GeoBasis Stations\Snowpatches photos*).

4. Microclimatology and Energy Balance

4.1. Introduction

In Kobbefjord several automatic weather stations monitor essential meteorological parameters at different surfaces and elevations as a part of the GeoBasis monitoring program. M300 (in 300 m a.s.l) is situated close to K1 and K2 and M500 (in 500 m a.s.l) close to K3 and K4. At the other site of the valley a former GeoBasis station M1000 (in 1000 m a.s.l.) is now driven by Asiaq and ClimateBasis. Data from this station is currently not available at the GEM database. However, data can be freely obtained by contacting Asiaq (Kirsty Langley) and is still updated in Wiski (GB02).

In the valley two Interact energy balance stations (one at the heath, and one in the fen) also monitor meteorological parameters together with snow and soil parameters. The soil station in the fen also monitors some meteorological parameters; this station is described under section 5.

ClimateBasis (Asiaq) has the two stations at the end of Badesø and when combining these stations with the GeoBasis stations the microclimatology of the valley can be investigated (daily air temperatures in 2015 at the different stations are seen in Figure 4.1).

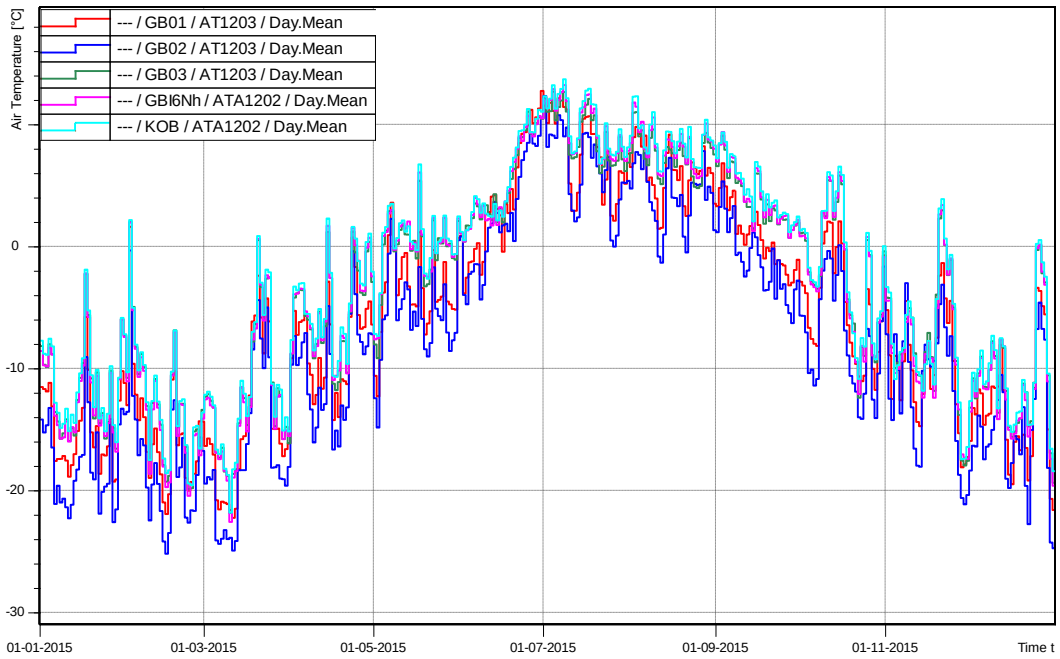


Figure 4.1 Daily mean temperatures in 2015 from five of the stations in Kobbefjord.GB01=M500, GB02=M1000, GB03=SoilFen, GB16Nh=InteractHeath, KOB=ClimateBasis

In the GEM database the meteorological data is found under ***GeoBasis Nuuk – Meteorology***

4.2. M300 (GB07)

4.2.1. Introduction

M300 is located at the same mountain top as K1 and K2 in 300 meters height. The main purpose of the mast is to provide Wi-Fi connection to the two Interact masts and the hut by the two antennas. The work includes collecting data, data quality checks, maintaining sensors, protecting the installations and administering station metadata (present and historic sensors, what program has been running when).

4.2.2. History

M300 was set up in 2017 and Wi-Fi connection to the two Interact stations and the hut was established. No sensors were mounted the first year, and the station only logged battery temperature and voltage. In 2018 a CS215 temperature and relative humidity sensor was mounted, and in 2019 the station was equipped with a SP Lite Pyranometer.

4.2.3. Frequency

M300 is visited whenever K1/K2 are visited (2-4 times a year).

4.2.4. Station check

At every station visit the sensors are visually inspected (sensor in level, firmly installed, damaged, condition of wires, enclosure, solar panel and mast). Station data can also be checked from hut.

How to go there: **Appendix 2 Camera guide**
Data download: **Appendix 4 Data Download CR1000 guide**
Access from the hut: **Appendix 9 Wi-Fi network**

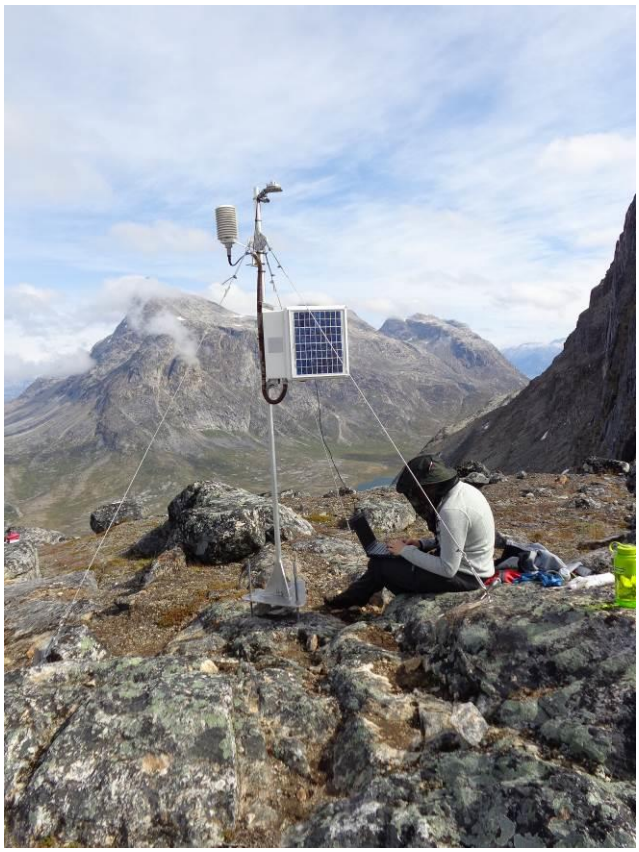
4.2.5. Start up in spring

Download data via Loggernet and afterwards change memory card. Change silica bags, 3 should be enough. If the enclosure during the season is not 100 percent dry, then change silica bags again. Otherwise, it is ok to change them only two times a year.

4.2.6. Close down in fall

Make sure sensors are OK, wires are tight, change silica bags, leave 4-6 bags for the winter; be sure water or snow cannot enter the enclosure. Make sure there is enough space on the memory card to log data during winter.

4.3. M500 (GB01)



4.3.1. Introduction

M500 is placed on the same mountaintop as K3 and K4 in 500 meters height. The work includes collecting data, data quality checks, maintaining sensors, protecting the installations and administering station metadata (present and historic sensors, what program has been running when).

4.3.2. History

M500 has been running since 2007.

4.3.3. Frequency

M500 is visited whenever K3/K4 are visited (2-4 times a year).

4.3.4. Station check

At every station visit the sensors are visually inspected (sensor in level, firmly installed, damaged, condition of wires, enclosure, solar panel and mast).

What to bring and how to go there: **Appendix 2 Camera guide**.
Data download: **Appendix 4 Data Download CR1000 guide**.

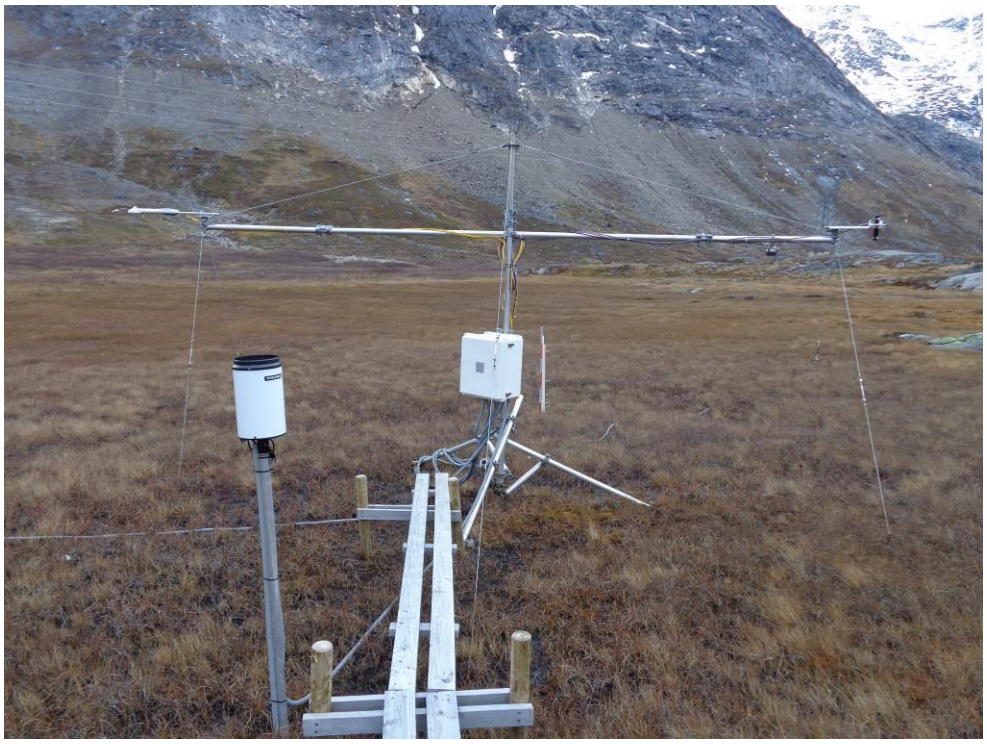
4.3.5. Start up in spring

Download data via Loggernet and afterwards change memory card. Change silica bags, 3 should be enough. If the enclosure during the season is not 100 dry then change silica bags again, otherwise it is ok to change them only twice a year.

4.3.6. Close down in fall

Make sure sensors are OK, wires are tight, change silica bags, leave 4-6 bags for the winter; be sure water or snow cannot enter the enclosure. Make sure there is enough space on the memory card to log data during winter.

4.4. Interact Fen (I5Nf)



4.4.1. Introduction

Interact Fen is one of the two automatic energy balance stations that was setup in 2011 by Interact. The stations are a part of a network of similar stations; in Nuuk we have station no. 5 (I5Nf) and 6 (I6Nh). GeoBasis take care of the daily checks and updates. Interact Fen is placed in the fen, where it is very wet. Be very careful when you walk outside the boardwalk, the vegetation is very easily damaged. Take some wood and walk on that, and be extra careful under the sensors. The work includes collecting data, data

quality checks, maintaining sensors, protecting the installations and administering station metadata (present and historic sensors, what program has been running when).

4.4.2. History

Interact Fen has been running since 2011. In 2013 the logger enclosure and program was changed. In 2017 a Wi-Fi antenna was mounted and the station can be accessed from the hut and now sends a data string by mail every day to Kerstin, Birger and Mathias.

4.4.3. Frequency

Interact Fen is visited once every 14 days.

4.4.4. Station check

At every other station visit, the sensors are visually inspected (sensor in level (twice a year), firmly installed, damaged, condition of wires, enclosure and mast). Especially the soil sensors is important to notice if the fox has been digging or if there are any other signs that the buried sensors may be physically damaged. Take very much care of the vegetation and do not step on the soil profile where the sensors are buried.

Data download: **Appendix 4 Data Download CR1000 guide**
Access from the hut: **Appendix 9 Wi-Fi network**

Pyranometer (incoming and outgoing short and long wave radiation).

Left: SR50 Snow Depth sensor, Right: NDVI sensor (Vegetation greenness).

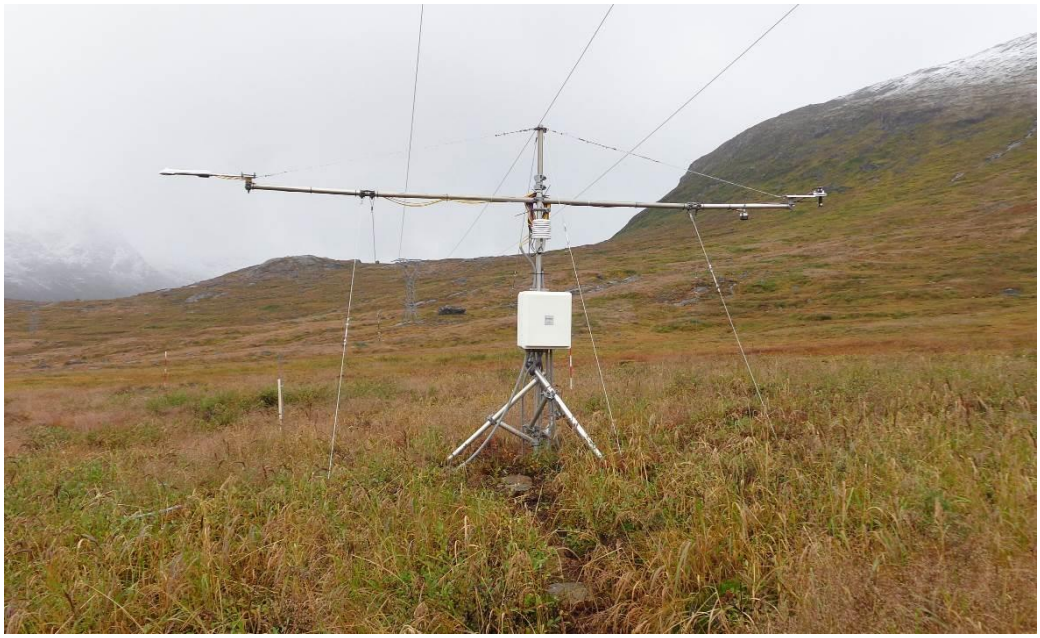
4.4.5. Start up in spring

Download data via Loggernet and afterwards change memory card. Change silica bags about 3-6, it have happened that water/snow have entered the enclosure during winter, so if the enclosure is not dry then dry up the enclosure, find the leakage and add 6-9 silica bags. If the enclosure during the season is not 100 percent dry then change silica bags again otherwise it is ok to change them only two times a year.

4.4.6. Close down in fall

Make sure sensors are OK, wires are tight, change silica bags leave 6-9 bags for the winter; be sure water or snow cannot enter the enclosure. Make sure there is enough space on the memory card to log data during winter.

4.5. Interact Heath (I6Nh)



4.5.1. Introduction

Interact Fen is one of the two automatic energy balance stations that was setup in 2011 by Interact. The stations are a part of a network of similar stations; in Nuuk we have station no. 5 (I5Nf) and 6 (I6Nh). GeoBasis take care of the daily checks and updates. Interact Heath is placed on the heath. The vegetation is VERY easily damaged especially the Empetrum plants, therefore only walk on the footpaths and enter the area along the stream. Be extra careful under the sensors. The work includes collecting data, data quality checks, maintaining sensors, protecting the installations and administering station metadata (present and historic sensors, what program has been running when).

4.5.2. History

Interact Heath has been running since 2011. In 2012, the station was moved 20 m closer to the stream because the vegetation was damaged underneath the sensors. In 2013, the logger enclosure and program was changed. In 2017, a Wi-Fi antenna was mounted, and the station can be accessed from the hut and now sends a data string by mail every day to Kerstin, Birger and Mathias.

4.5.3. Frequency

Interact Heath is visited once every 14 days.

4.5.4. Station check

At every other station visit the sensors are visually inspected (sensor in level (twice a year), firmly installed, damaged, condition of wires, enclosure and mast). Especially the soil sensors is important to notice if the fox has been digging or there are any other signs that the buried sensors may be physically damaged. Take very much care of the vegetation and do not step on the soil profile where the sensors are buried. Station data can also be checked from the hut now.

Data download: **Appendix 4 Data Download CR1000 guide**.
Access from the hut: **Appendix 9 Wi-Fi network**

4.5.5. Start up in spring

Download data via Loggernet and afterwards change memory card. Change silica bags about 3 should be enough. If the enclosure during the season is not 100 percent dry then change silica bags again otherwise it is ok to change them only two times a year.

4.5.6. Close down in fall

Make sure sensors are OK, wires are tight, change silica bags leave 4-6 bags for the winter; be sure water or snow cannot enter the enclosure. Make sure there is enough space on the memory card to log data during winter.

5. Soil monitoring

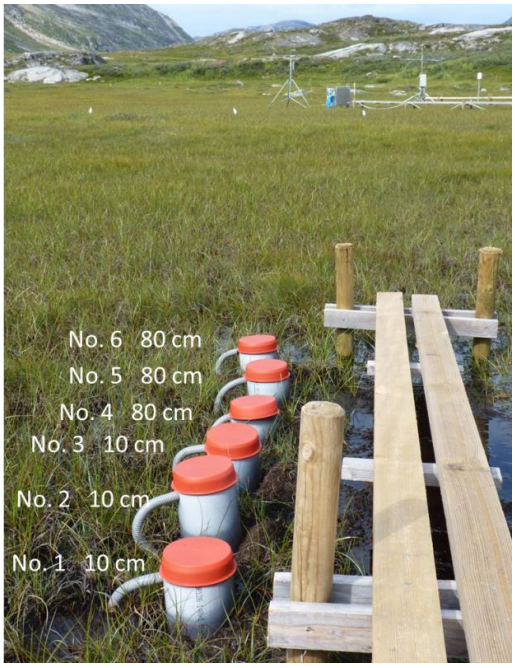
5.1. Introduction

GeoBasis Nuuk has currently three soil stations placed at different vegetation surfaces; SoilFen (moist soil and grasses), SoilEmp (dominated by empetrum) and SoilEmpSa (dominated by empetrum and salix). The stations automatically measure the thermal regime of the soil column, soil moisture in different depths and the soil heat flux. The two Interact stations also measures soil temperatures, water level (in the Fen), soil moisture and soil heat flux, but these stations are described in section 4.

The data from the soil stations can be used to investigate the interactions between the soil conditions and the vegetation, gas fluxes and energy balance in the area. Furthermore, the influence of the snow pack on the soil thermal regime and the soil water content can be studied.
At the SoilFen station, soil water is sampled manually from two depths during the field season, to study how hydrology in turn controls the material and nutrient export from soils to surface waters. Compared to other components of the hydrological cycle, the volume of soil moisture is small; nonetheless, it is of fundamental importance to many hydrological, biological and biochemical processes.
Earlier, soil water was also collected at the heath (until 2016) and SoilEmp (until 2013), but the sampling was stopped due to too dry soil.

In the GEM database the soil properties data is found under ***GeoBasis Nuuk – Soil Properties***

5.2. SoilFen (GB03)



5.2.1. Introduction

SoilFen is one of the three automatic soil stations. SoilFen is placed in the fen and consist of an automatic station and a soil water station. The work includes collecting data, data quality checks, maintaining sensors, protecting the installations and administering station metadata (present and historic sensors, what program has been running when) and soil water sampling.

Soil water is collected at 10 cm (three replicas) and 80 cm (three replicas) depth, using soil water samplers (suction cup lysimeters) from Prenart. The suction sampler used in Nuuk is 'Prenart Super Quartz' which is made of porous PTFE (teflon) and quartz.

5.2.2. History

SoilFen has been running since 2007. In 2008 the station was redesigned because it was flooded. In 2008 the soil water was implemented. In 2012 the boardwalk was build.

5.2.3. Frequency

SoilFen is visited once every 14 days, soil water is collected once in the beginning of the growing season, once or twice during the growing season and once at the end of the growing season.

5.2.4. Station check

At every station visit the sensors are visually inspected (sensor in level, firmly installed, damaged, condition of wires, enclosure, solar panel and mast). Especially at the soil stations it is important to notice if the fox has been digging or there are any other signs that the buried sensors may be physically damaged. Take very much care of the vegetation and do not step on the soil profile where the sensors are buried.

For collection and laboratory analysis of soil water: **Appendix 3 Soil water guide**

Data download: **Appendix 4 Data Download CR1000 guide**.

5.2.5. Data handling

Field Chart 4 is completed with the laboratory results from Nuuk (pH and conductivity) and is saved under *P:\B53_Nuuk_Basic\b53-06 GeoBasis\GeoBasis Stations\SoilFen\Soil Water Chemistry*

Soil water samples are collected in brown bottles and send to Copenhagen by the end of the season for additionally analyses. An overview of the soil water analyses is given in Table 5.1.

Table 5.1 Parameters analyzed in the GeoBasis program

Is analyzed where	*Parameter*
GEOBASIS	pH
GEOBASIS	Conductivity
GEOBASIS	Alkalinity
GEOCENTER	Chloride (Cl-)*
GEOCENTER	Nitrate (NO3-)*
GEOCENTER	Sulfate (SO42-)*
GEOCENTER	Calcium (Ca2+)
GEOCENTER	Magnesium (Mg2+)
GEOCENTER	Potassium (K+)
GEOCENTER	Sodium (Na+)
GEOCENTER	Iron (Fe2+)
GEOCENTER	Aluminum (Al3+)
GEOCENTER	Manganese (Mn2+)
BIOBASIS (Department of Biology, University of Copenhagen)	Dissolved organic carbon (DOC)*
BIOBASIS (Department of Biology, University of Copenhagen)	Ammonia (NH4+-N) *
BIOBASIS (Department of Biology, University of Copenhagen)	Dissolved total nitrogen (DTN)*
*The only parameters found in soil water samples in Kobbefjord	

5.2.6. Replacement of suction probes

Suction probes can work for years without any problems but clogging and bad hydraulic contact may cause problems and require replacement. In that case follow the procedure for installation given by Prenart Equipment ApS. Installation dates are noted in the GeoBasis Field journal.

5.2.7. Labels and bottles

The water samples sent to Copenhagen must be labeled according to the following convention: GB01-20140804-80-6 (Soil water station in fen, collected 4/8-2014 from depth 80 cm, sample no. 6). If you need more labels, they are found at Asiaq:
P:\B53_Nuuk_Basic\b53-06 GeoBasis\Misc\Field charts\Lables til soil water.doc.
Remember: when you print, choose "print from **magasin 5"** and use the label paper with 24 labels **no. 57159.** Place the paper with the back side upward. The bottles are found in the left drawer in the laboratory in the hut. Birger can send or bring new bottles, when needed. Just remember to tell him.

5.2.8. Storage and transport

Keep the brown sample bottles cold and store them in the Asiaq workshop freezer and fridge as soon as possible. By the end of the season all the bottles are packed in two insulated boxes and sent to Birger. Find shipping *labels here: P:\B53_Nuuk_Basic\b53-06 GeoBasis\Misc\Div\Fragt\Shipping Labels*

Send the bottles as refrigerated cargo (+5°C) and frozen cargo (-18°C) with Blue Water Shipping. It is a good idea to insulate the frozen cargo box with polystyrene (flamingo) and leave some refrigeration units in it.

The polystyrene can be bought in STARK – but check out the “koldlager” or the room next to the cooking equipment at the workshop before buying.

It is cheaper to send it with airmail than with ship because the shipping from Aalborg to Copenhagen is extremely expensive (around 1000 kr). Bring the boxes with the samples to Blue Water.
Remember to fill out the excel sheet with results of the soil water analysis and send it to Birger by the end of the season. It is important for the laboratory people in Denmark.
\\ASIAQFIL001\Projekt\B53_Nuuk_Basic\b53-06 GeoBasis\GeoBasis Stations\SoilFen\Soilwater chemistry\field charts indskrevet

5.2.9. Start up in spring

When the ice in the fen has thawed; push down the three large metal sticks inserted in the peat for holding the wires which are stabilizing the metal stand for the solar panel + logger box + sensors in order to tightening the wires. Make sure that the metal stand is in vertically level. Download data via Loggernet and afterwards change memory card. Change silica bags, about 3 should be enough. If the enclosure during the season is not 100 percent dry then change silica bags again, otherwise it is ok to change them only two times a year.

Clean the soil water bottles, lids and tubing in clean water and with a sponge and paper. Remove algae and other dirt, be careful when cleaning inside the bottle, do not use the same sponge inside the bottles. Use instead clean paper and rinse with clean water afterwards. Empty the gray tubes for water. Spare lids are found in the soil water box in the hut.

5.2.10. Close down in fall

Make sure sensors are OK, wires are tight, change silica bags, leave 4-6 bags for the winter; be sure water or snow cannot enter the enclosure. Make sure there is enough space on the memory card to log data during winter.
Leave the 1L soil water plastic bottles at the site.

5.3. SoilEmp (GB04)

5.3.1. Introduction

SoilEmp is one of the three automatic soil stations. SoilEmp is placed on empetrum (crowberry/revling) vegetation on the eastern side of the river. The work includes collecting data, data quality checks, maintaining sensors, protecting the installations and administering station metadata (present and historic sensors, what program has been running when).

5.3.2. History

SoilEmp has been running since 2008. The station was constructed with soil water in 2008 but in 2013 the soil water part was removed because the site was too dry.

5.3.3. Frequency

SoilEmp is visited once every 14 days.

5.3.4. Station check

At every station visit the sensors are visually inspected (sensor in level, firmly installed, damaged, condition of wires, enclosure, solar panel and mast). Especially at the soil stations it is important to notice if the fox has been digging or there are any other signs that the buried sensors may be physically damaged. Take very much care of the vegetation and do not step on the soil profile where the sensors are buried.

Data download: **Appendix 4 Data Download CR1000 guide**.

5.3.5. Start up in spring

Download data via Loggernet and afterwards change memory card every other year. Change silica bags about 6. This enclosure have sometimes been wet inside after winter so check if there are dew and try to dry it up. If the enclosure during the season is not 100 percent dry then change silica bags again, otherwise it is ok to change them only two times a year.

5.3.6. Close down in fall

Make sure sensors are OK, wires are tight, change silica bags leave 6-9 bags for the winter, be sure water or snow cannot enter the enclosure. Make sure there is enough space on the memory card to log data during winter.

5.4. SoilEmpSa (GB05)

5.4.1. Introduction

SoilEmpSa is one of the three automatic soil stations. SoilEmpSa is placed on empetrum (crowberry/revling) vegetation and Salix (willow/pil) vegetation on the eastern side of the river. The work includes collecting data, data quality checks, maintaining sensors, protecting the installations and administering station metadata (present and historic sensors, what program has been running when).

5.4.2. History

SoilEmpSa has been running since 2008. In the beginning, there were many problems with foxes.

5.4.3. Frequency

SoilEmpSa is visited once every 14 days.

5.4.4. Station check

At every station visit the sensors are visually inspected (sensor in level, firmly installed, damaged, condition of wires, enclosure, solar panel and mast). Especially at the soil stations it is important to notice if the fox has been digging or there are any other signs that the buried sensors may be physically damaged. Take very much care of the vegetation and do not step on the soil profile where the sensors are buried.

Data download: **Appendix 4 Data Download CR1000 guide**.

5.4.5. Start up in spring

Download data via Loggernet and afterwards change memory card every other year. Change silica bags about 3 should be enough. If the enclosure during the season is not 100 percent dry then change silica bags again, otherwise it is ok to change them only two times a year.

5.4.6. Close down in fall

Make sure sensors are OK, wires are tight, change silica bags leave 4-6 bags for the winter; be sure water or snow cannot enter the enclosure. Make sure there is enough space on the memory card to log data during winter.

6. Gas Flux Monitoring

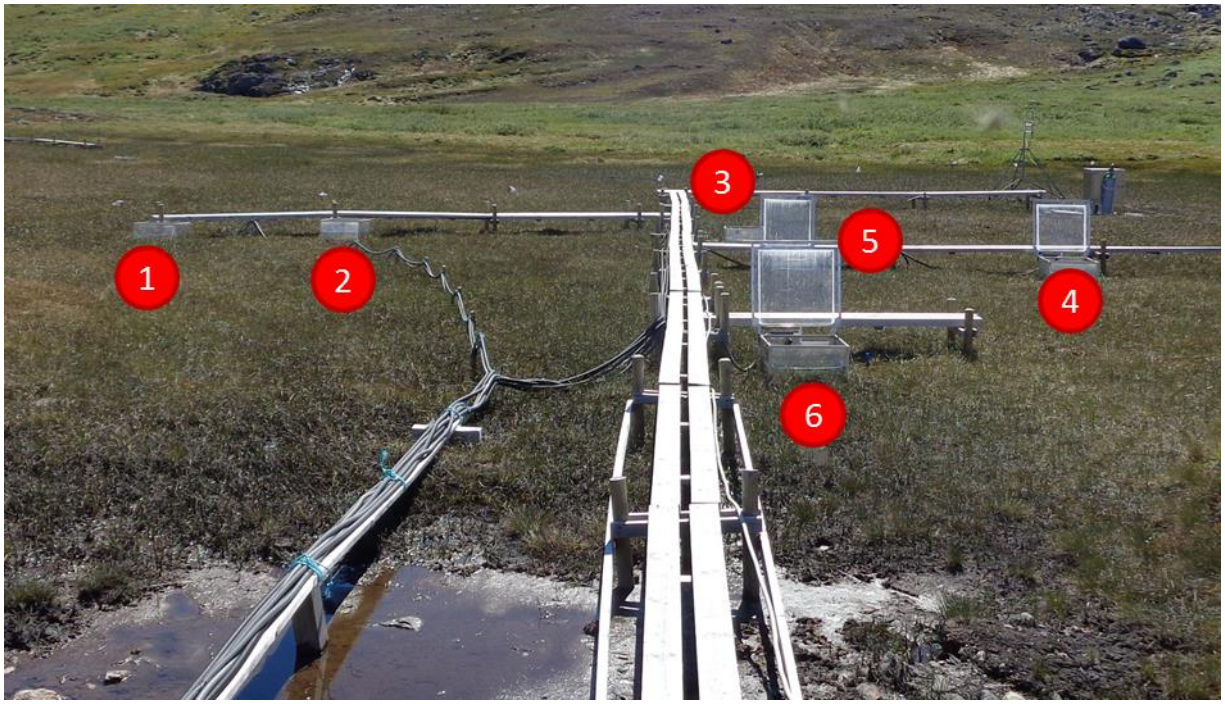
6.1. Introduction

Arctic ecosystems contain large stocks of soil organic carbon as a result of many years of net accumulation due to the cold climate and hence, slow decomposition. With a warmer and wetter climate, the greenhouse gas fluxes between land and atmosphere are changing. GeoBasis monitors greenhouse gas concentrations at the heath and in the fen in Kobbefjord. The concentrations are used to calculate fluxes and carbon budgets for the different vegetation types and to study the variation in fluxes under changing meteorological conditions and seasonal and annual variations.

In the fen a methane monitoring setup with six automatic chambers together with an eddy covariance tower are monitoring the methane (Methane Station) and CO_2 concentrations (Eddy Fen and Methane Station). At the heath the Eddy Heath station is monitoring the CO_2 concentrations. The gas flux monitoring is only running during the field season because staff is needed to maintain the stations (methane) and because of too little power in winter (all stations).

Data from the Methane station is found in the GEM database under ***GeoBasis Nuuk – Fluxmonitoring*** The flux data from Eddy Heath and the newest data from the Methane Station and Eddy Fen is currently not available in the GEM database. Please contact Birger Hansen if data is needed.

6.2. Methane station



6.2.1. Introduction

The Methane station (LGR) measures the methane flux in the fen during the field season (app. end of May until mid-October). Methane is not very important with respect to the carbon budget compared to CO_2 but it is a very potent greenhouse gas. Methane is produced by anaerobe microbial decomposition of organic matter. The station is placed in the fen, where it is very wet and there is up to more than 1 m of peat. These conditions are in favor of methane production.

The system consists of six automatic chambers that opens and closes. When a chamber closes an analyzer monitors the CO_2 and CH_4 concentration within the closed chamber. The measurement system has its own extensive **Operator's Manual** (by Mikhail Mastepanov). A hard copy is found in the folder in the LGR shelter.

When the Methane station is running, the power consumption in the fen is high. Therefore, it can be necessary to turn on the GeoBasis generator at the hut especially by the end of the season, when the sun is low or on cloudy, calm days. This is described in **Section 9.2.9**.

6.2.2. History

Methane station has been running since 2007. Since 2009 the analyzer was placed in a permanent shelter and all wires were installed in protective hosing. In 2014 chamber 3 and 4 were relocated to new spots and got new tubing. In 2016 the lids got renovated and chamber 1, 2, 5 and 6 got new tubing. In 2019 chambers 1, 2 and 3 were changed to new chambers, and 4-6 will be changed in 2020.

6.2.3. Frequency

Methane station is visited at almost every visit in Kobbefjord.

6.2.4. Station check

At every station visit **Field chart 2** is filled out, at least once a week everything is filled out. **See Appendix 8**. Twice during the field season, the piezometers must be leveled (nivelleret) and the chamber volume measured. See last page in **Appendix 8.**

A trouble-shooting guide is found in the methane hut. Consult this and old field charts, if you have problems with the station.

6.2.5. Start up in spring

See guide in **Operators manual for CH4 and CO2 flux monitoring system**.

Please notice that the start-up of the station includes a lot of carrying (lids for chambers, fans, motors and tubing) and expect at least two days for mounting the system. Especially the mounting of lids and motors can be tricky. It is preferable to be two persons for this job.

Remember to clean the lids and rinse the tubes with compressed air. Use the vacuum pump – it can be done in the field, but remember to charge the pump in the hut.

6.2.6. Close down in fall

By the end of the field season, the methane station is disassembled.

Expect at least a whole day dismounting the system, maybe even more in cold and windy weather.

Remember that the work includes a lot of carrying – it is preferable to be at least two persons for this job!

The procedures regarding removal of the lids, fans, engines and analyzer are described in the **operator's manual**. However, there are a few other things to remember:

Before the fen site begins to freeze (normally around mid-September) the tubes in protective hoses must be elevated at least 20 cm above the peat surface. Otherwise they will freeze in as ice builds on top of the peat.

The chamber frames must be marked out with a range rod in front of each chamber so that the chambers can be located next spring/during the snow survey. The shelter is left over winter. Clean the lids (remove the white mark made by the sealing on the lid). The LGR analyzer is brought back to Nuuk. The lids, motors, fans and tubing are numbered (Chamber no.) and placed in the storage hut. The storm sensor is demounted and placed inside the hut on the GeoBasis shelves.

Before storing or at least before spring start-up it is a good idea to rinse the tubes with compressed air.

6.3. Eddy Fen

6.3.1. Introduction

The Eddy Fen station measures carbon dioxide fluxes via eddy covariance method in the wet fen site. In order to describe the inter-annual variability of the seasonal carbon balance, net ecosystem exchange (NEE) of carbon dioxide (CO_2) is measured using the eddy covariance method. Staff is needed to maintain these measurements and data are therefore only collected in the field season.

6.3.2. History

Eddy Fen has been running since 2007. In 2017 the old Li-Cor 7000 had many problems and it was decided to set up a new Li-Cor system. In August 2018 a new Li-Cor and a SmartFlux were installed.

6.3.3. Frequency

Eddy Fen station is visited every 14 days.

6.3.4. Station check

At every visit the system is checked by following **Appendix 6 Eddy Fen & Eddy Heath Guide.** Check if the pump is running and check station visually.

6.3.5. Internal chemicals and mirror cleaning

The internal chemicals should be changed every second year (preferably in spring when the housing temperature is changed). If values start to look very strange, it could be that the mirror needs

cleaning, see **Appendix 6 Eddy Fen & Eddy Heath Guide.** The avg. signal strength is a coarse indicator of when to clean the instrument. An avg. signal strength of 100 is very clean, 80 is relatively dirty, 50 is very dirty and 0 is no signal at all. The mirror should be cleaned every year at season start.

6.3.6. Calibration

Calibration test is performed during start up, end of season and app. once a month if data is out of limit. Use **Appendix 6 Eddy Fen & Eddy Heath Guide.**
If sensor head is send to factory calibration, remember to fill in correct calibration coefficients, when it is mounted again.

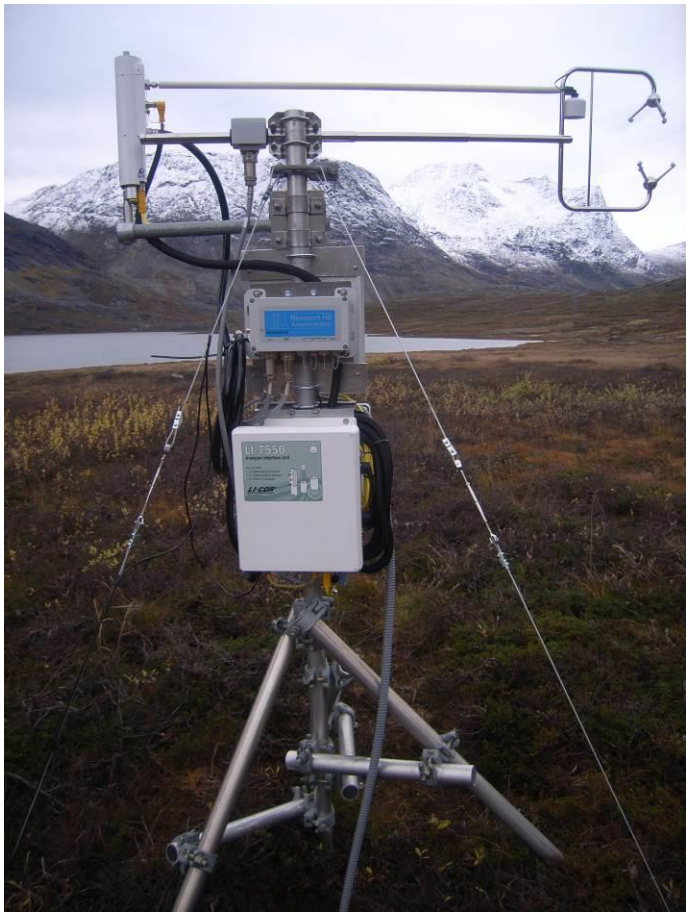
6.3.7. Start up in spring

- Remove the fox net and place it in the hut.
- Turn on the station (connect to power in the small battery box)
- Make a calibration check (**Appendix 6**).
- Clean window (**Appendix 6**).
- Change chemicals every other year (see Li7200 manual) (2018, 2020, 2022…).
- Change silica bags. 3 in each enclosure.
- Tighten wires.

6.3.8. Close down in fall

Turn off the station (unplug cable in the small battery bank). Remember to protect the station with fox net so the foxes cannot destroy the cables in the winter, when they can reach the cables due to 1 m snow. Change silica bags 3-6 in each enclosure.

6.4. Eddy Heath



6.4.1. Introduction

The Eddy Heath station measures carbon dioxide fluxes via the eddy covariance method on the heath site. In order to describe the inter-annual variability of the seasonal carbon balance, net ecosystem exchange (NEE) of carbon dioxide (CO_2) is measured by applying the eddy covariance method. The station uses a lot of power and in the winter the power supply is too small, therefore data is only collected in the field season.

6.4.2. History

Eddy Heath has been running since 2012.

6.4.3. Frequency

Eddy Heath station is visited every 14 days Kobbefjord.

6.4.4. Station check

At every station visit, screen shots are taken. See **Appendix 6 – Eddy Fen & Eddy Heath guide**.

6.4.5. Internal chemicals and mirror cleaning

The internal chemicals should be changed every second year (preferably in spring when the housing temperature is changed). If values start to look very strange, it could be that the mirror needs cleaning, see the Licor7200 manual (‘**Li-7200, CO2/H2O analyzer, Instruction manual’**) for details. The avg. signal strength is a coarse indicator of when to clean the instrument. An avg. signal strength of 100 is very

clean, 80 is relatively dirty, 50 is very dirty and 0 is no signal at all. The mirror is cleaned every year at season start.

6.4.6. Calibration

Calibration test is performed during start up, end of season and app. once a month if data is out of limit.
Use **Appendix 6 – Eddy Fen & Eddy Heath guide**.
If the sensor head is send to factory calibration, remember to fill in correct calibration coefficients, when it is mounted again.

6.4.7. Start up in spring

- Remove the fox net and place it in the hut.
- Turn on the station (connect to power in the power hut)
- Make a calibration check (**Appendix 6**).
- Clean window (**Appendix 6**).
- Change chemicals every other year (see Li7200 manual) (2018, 2020, 2022…).
- Change silica bags. 3 in each enclosure.
- Tighten wires.

6.4.8. Close down in fall

Turn off the station (unplug cable in the power hut). Remember to protect the station with fox net so the foxes cannot destroy the cables in the winter when they can reach the cables due to 1 m snow. Change silica bags 3-6 in each enclosure.

7. Snow Monitoring

7.1. Introduction

Snow distribution and properties are important parameters in the control of arctic climate and ecosystem processes. The snow affects the vegetation, the length of the growing season, the thermal regime and the moisture of the soil and hence, indirectly the greenhouse gas production.
It also alters the surface albedo and thereby affects the energy balance of the ecosystem, insulates the ground and is an important part of the hydrological system.

In Kobbefjord several automatic snow sensors are installed. At the heath a Snow Pack Analyzer (SPA) measures snow temperatures, densities, snow water equivalents and snow depths, while both Interact Heath and Interact Fen measure snow depths and snow temperatures in different depths (Section 4). The six automatic cameras (Section 3.2) are used to validate data and analyze the snow distribution at a larger scale. ClimateBasis also has two SR50 sensors at the climate stations, which measure values comparable to the values from Interact Heath.
Every year in spring, manual snow measurements are conducted in collaboration with ClimateBasis and Asiaq (**Appendix 10**).

Snow data from the Interact stations is found in the GEM database under ***GeoBasis Nuuk – Snow Properties.***
Data from the SPA station is currently not available in the GEM database but can be obtained by contacting Kerstin Rasmussen. The snow survey data is published in an Asiaq report. Contact Kerstin Rasmussen or Kirsty Langley for that.

7.2. SPA (Snow Pack Analyzer)

7.2.1. Introduction

The SPA station measures snow depth, snow weight, snow type at the heath site. A similar station is found in Zackenberg. The work includes collecting data, data quality checks, maintaining sensors, protecting the installations and administering station metadata (present and historic sensors, what program has been running when).

7.2.2. History

SPA station has been running since 2013. It has been a problem to download data, and Mathias has been in contact with Sommer, the company making the SPA.

7.2.3. Frequency

SPA station is visited every other week in Kobbefjord.

7.2.4. Station check

See **Appendix 7 – SPA guide**.

7.2.5. Start up in spring

Download data. Change silica bags, about 3 should be enough. If the enclosure during the season is not 100 percent dry then change silica bags again, otherwise it is ok to change them only two times a year.

7.2.6. Close down in fall

Make sure sensors are OK, wires are tight, change silica bags leave 4-6 bags for the winter; be sure water or snow cannot enter the enclosure.

7.3. Snow Survey

7.3.1. Introduction

The snow survey in Kobbefjord is done in order to understand the spatial variation of the snow cover and snow properties in the fiord better. Snow pits are made close to the automatic stations of the GeoBasis and ClimateBasis monitoring programs and data can be used to investigate how the snowpack influences the underlying ground and vegetation and the energy balance of the area.
The survey is done as a cooperation between ClimateBasis (Asiaq) and GeoBasis.
Data from the survey is not available in the GEM database but is published each year in an Asiaq Report. Contact Kirsty Langley or Kerstin Rasmussen for that.

7.3.2. History

The snow survey in Kobbefjord has been done at least once per snow season since 2009.

7.3.3. Frequency

The survey is done as close to the snow depth maximum as possible. It is however difficult to find the best timing. Until 2015 two surveys were done for most snow seasons. In 2016 almost all snow was gone by the time of that year's single survey and it was suggested to start having two surveys again, but the procedure has not yet been changed.

7.3.4. Tasks

The snow survey includes:

- Snow pits (stratigraphy, temperature, density) at four-five locations
- Cross transects of 2 x 100 m (snow depth measurements with DGPS at every 2 m) at each snow pit site
- Several travel transects (snow depth measurements with probe at every 50 m) across the valley
- Two grids (snow depth measurements with probe)
- Since 2018 a drone flight for a winter DEM

While in the fiord for the snow survey, the GeoBasis stations should be check, data offloaded and distances from snow depth sensors (Interact stations and SPA) to snow surface should be measured together with the snow depth close to the sensors. Before the snow survey it is important to make a list of other relevant GeoBasis tasks in the fiord. Heavy equipment (garbage and other) can be transported in winter with snowmobile or sleds!

Remember to bring as much of the equipment for the snow survey as possible by the end of the summer field season. It is much easier to bring the equipment by boat in autumn than carry it over the fiord ice during winter.

The manual and guides for the Snow survey is found here:
\\ASIAQFIL001\Projekt\B53_Nuuk_Basic\b53-04 Snemonitering\Info
And in **Appendix 10 – Snow survey info**.

8. River Water Monitoring

8.1.1. Introduction

The river water in Kobbefjord by the research station is much diluted and carries very little suspended material. GeoBasis monitors seasonal variations in the river water electro chemistry by measuring the river's pH, temperature and conductivity. Data is not yet in the GEM database.

8.1.2. History

Measurements in the river have been done since 2009. In 2012 we stopped taking water samples from the river because there were no minerals or sediments in the river, however if something is looking special (suddenly a lot of algae/sediments/water in the river) it can be a good idea to take a sample anyway. From 2018 a bottle of water is brought back to hut where the pH is measured in the afternoon. Temperature and conductivity are still measured directly in the river.

8.1.3. Frequency

The river water electrochemistry is measured every day you are in the Kobbefjord during the field season and occasionally during winter.

8.1.4. Station check

See **Appendix 5 – River water guide** and use **Field Chart 5**

8.1.5. Data handling

Data from field charts is written into a digital version located here:

..\..\..\GeoBasis Stations\River Water Chemistry\field charts indskrevet\River_water_indskrevet.xls or it can written directly into the excel sheet using the field tablet.
By the end of the season the excel document is sent to Birger.
If any water samples are taken, the date and number of the sample should be registered in an excel sheet as well, as documentation for the person handling the sample in Copenhagen.

8.1.6. Start up in spring

Bring calibration solutions and 'suitcase' with analyzer to Kobbefjord and start measure as early as possible. If the air temperatures are still low then wait to bring the solutions until the temperature stays above 0 degrees and take the suitcase with you back to Asiaq every time.

8.1.7. Close down in fall

Calibration solutions should be brought to the office, as they are sensitive to low temperatures. The 'suitcases' with the instruments should also be brought back to Asiaq for winter storage. Order new calibration solutions if the old ones are out of date for next season and bring the pH and conductivity electrodes and meters with you to Copenhagen for testing/calibration.

9. Power supply

9.1. Introduction

All GeoBasis stations in Kobbefjord are primarily powered by solar and wind energy.
At the heath, there are four solar panels and one windmill, in the fen, six solar panels and two windmills. When the Methane Station is turned on, it can be necessary to turn on the GeoBasis generator for additional power supply for the fen.

9.2. Power Fen

9.2.1. Introduction

Power Fen supplies the Methane station, the Eddy Fen station and the Interact station. There are six solar panels, two wind generators, and a cable to the generator hut where the generator can charge the batteries in the fen. In the big battery bank at the rock there are eight 100 A batteries. Under the solar panel a battery box with four 100 A batteries are placed (charged by the windmills). In a smaller box next to the Eddy Station a small 7.2 Ah battery is placed to provide power for the InteractFen in the autumn, when solar energy is limited, to prevent the Interact station from “dying” if the flux stations use all the energy from the big battery bank. It is possible to change power source for the Interact station in this box. The Eddy Station should always be connected to the big battery bank.

9.2.2. History

The six solar panels and the eight 100 A batteries were set up in 2008. In 2012 the batteries was replaced by new batteries. In 2014 the two wind generators was set up together with the extra four 100 A batteries. In 2014 and again in 2017 we had a new generator. The small extra battery for the Interact station was added in 2016, but was flooded in spring 2017 and reinstalled in 2019.

9.2.3. Frequency

Power Fen is visited at every visit in the Fen.

9.2.4. Station check

For the big battery bank check the regulator to the left in the box and write down in the field journal:

- **SOC:** How many % the batteries are filled.
- **BAT:** The voltage on the batteries. When the generator is on the voltage will be high and around 13.8, note therefore if the generator is on, if the sun is shining and if windmills are running when you take the readings.
- **IN:** How much the solar panels produce.
- **OUT:** How much energy the stations use. (Methane around 5 A, Eddy Fen around 4 A, Interact Fen around 0,3 A)

Keep an eye on the small battery bank close to the Eddy Station. Switch Interact Cable from small battery bank to big, if the voltage on the small battery is too low. In the autumn the Interact Station should be connected to the small battery, if the flux stations are running.

9.2.5. Batteries

The big battery bank consists of 12 * 100 Ah batteries, 12 V. Each battery weighs 32.5 kg. The voltage on the batteries should be around 12.5-13.5. If it gets under around 12.5 connect the station to the generator.

9.2.6. Winter

The Interact mast in the fen is running during the winter. Three solar panels and the wind generators are connected during the winter and the Interact station should be connected to the big battery bank.

9.2.7. Solar panel

There are six 140 W solar panels that charge the battery bank. In clear sky periods the system supports a consumption of 120 W from mid-June until the end of August. But outside this period and in overcast conditions the solar panels need to be supported by the generator from the generator hut.

When starting up the station in spring, the snow's reflection of the sun can cause the solar panels to produce 200 W per solar panel. The system charge regulator Steca Tarom 245 is only designed to manage a 45 A current from the solar panels. **Therefore it is advisable to connect only three of the six solar panels as long as the snow cover is present.** Failure to do so will cause the regulator to periodically turn off the power outlet. If snow falls very early in the season this could be a problem too. In that case keep an extra eye on the power station and consider disconnecting half of the solar panels. However it is very rare that there are problems during autumn, because the sun will be behind the mountains for most of the day.

9.2.8. Start-up and shut-down off power supply and solar panels

Before shutting down the power supply and solar panels it is very important to make sure that the CO_2-station, methane station and Interact station are closed down.

To start up the equipment always start with the solar panels, then turn on the power supply. If any adjustments are needed to the system, always follow this order: Connect batteries to the regulator, first (+) then (-), turn on solar panels, first (+) then(-), set 'load on'. The other way: set 'load off' on the regulator, disconnect the solar panels, first (-) then (+), disconnect the regulator from the batteries, first (-) then (+).

Starting up the solar panels

1. Open the white connector box on the side of the battery box.

2. Switch on (+).
3. Switch on (-).

Starting up the power supply

1. Open the Steca Tarom regulator (the black box) inside the battery box.
2. Push MENU and wait.
3. Select 'menu' with the arrow up button.
4. Push arrow up x 1 to 'manual discon' appear on the display.
5. Push OK.
6. Push arrow down x 1 to 'load on' appear on the display.
7. Push OK.
8. Push MENU.

Shutting down the power supply

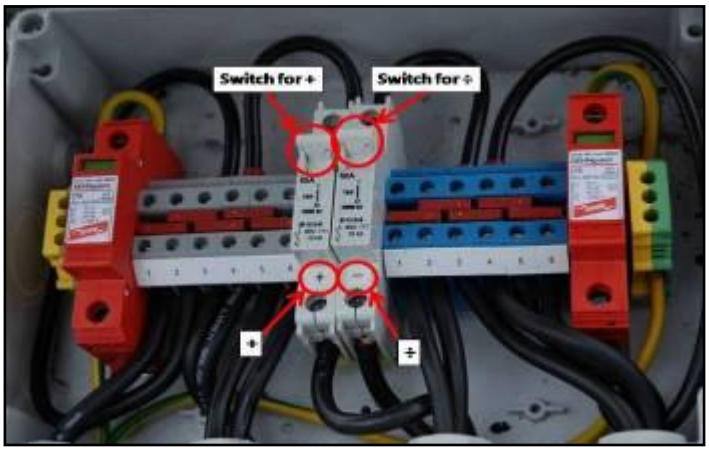
1. Open the Steca Tarom regulator (the black box) in the battery box.
2. Push MENU and wait.
3. Select 'menu' with the arrow up button.
4. Push arrow down x 2 to 'manual discon' appear on the display.
5. Push OK.
6. Push arrow down x 1 to 'load off' appear on the display.
7. Push OK.
8. Push MENU.

Shutting down the solar panels

1. Open the white connector box on the side of the battery box.
2. Switch off (-).
3. Switch off (+).

Tarom 245 with open lid.

Menu commands.



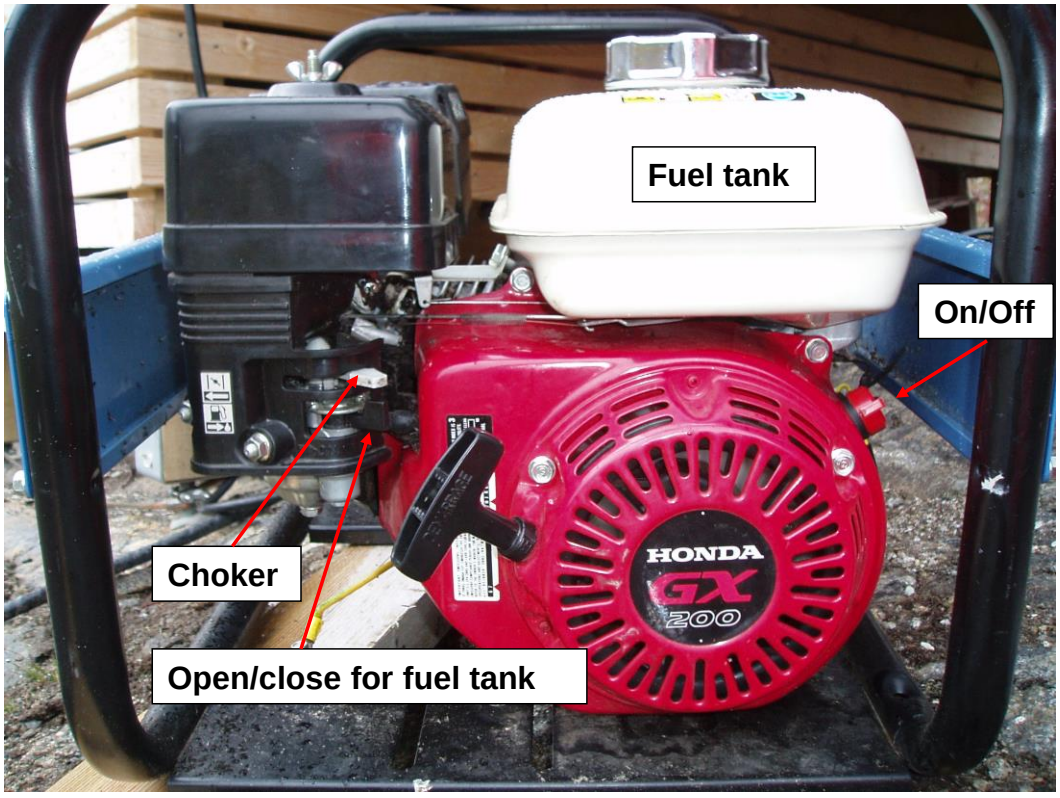
Connector box (Phaesun box) for the solar panels.

9.2.9. Generators

The generators are stored in the generator hut. The GeoBasis generator (marked GeoBasis and 3200 on side) is used for charging the 12 batteries in the battery bank in the fen site when charge from the solar panels is not big enough. The generator can be attached to a larger 55L tank, so that it can run for several days. Before attaching the big tank it should be emptied and dried off with a cloth before filling in new fuel. This is due to water accumulating in the tank, which will make the generator not run. Every year there are some issues with the generator, if you experience this try going through the 'trouble-shooting' list further down.

Generator with external tank.

When using the generator, make sure that the dial (red ring on picture below) in the charging box east of the battery bank always is on 'I' so that the batteries are charged the moment you turn on the generator.



The generator when it is running (now the generator has green frame!).

9.2.10. Starting the generator

1. Place the generator just outside the generator hut on the left side of the door on the wooden terrace.
2. Fill the fuel tank with petrol (benzin) from the red jerry cans; use a funnel (right wall inside the generator hut).
3. Switch the On/Off bottom to On.
4. Open for the fuel by sliding the black tap to the right.
5. Place the Choker halfway to the left.
6. Start the generator by pulling the handle in the string a few times – if it doesn't start wait a minute (for the fuel to run into the generator) - then pull again.
7. Move the choker to the right when the generator is started and the revolutions will increase.
8. Let the generator run for a minute before plugging in the plug /cable for the hut (the cable is on the left side of the hut or under the wooden terrace to the left side).

9.2.11. Shutting down the generator:

1. Disconnect the cable for the hut.
2. Close the fuel by sliding the black tap to the left.
3. Switch the On/Off bottom to Off.
4. Place the generator in the generator hut.

9.2.12. Troubleshooting

Problems with the generator can be due to several issues. Here are some suggestions for initial check:

- If the generator had been on recently, you might have to turn off the choker to be able to turn it on.
- Check if there is oil on the generator.
- Check if oil and fuel has mixed (generator has been 'drowned').
- Check if there is water in the fuel (will stand out as small, flat bobbles with a different color).
- Check if the generator engine produces enough watt to cover us (check V and A in the charging box, V*A = W). The E3200 generator should cover 2200W, but not more than 75% of this should be used.

Otherwise ask Philip or the boatmen for help!

9.3. Power Heath

9.3.1. Introduction

Power Heath supplies the Eddy Heath station, SPA and the Interact Heath station. There are four solar panels and one wind generator. The battery bank consists of eight 100 A batteries. Consumption: Eddy Heath around 4 A, Interact Fen and SPA around 0.3 A.

9.3.2. History

In 2011 the Heath site was build, and from 2011 to 2013 the power was delivered by an Efoy fuel cell. The system was very unstable and destroyed by frost. In 2013 the wind generator was set up together with the small solar panel charging four batteries. In 2014 the four big solar panels was set up and the extra four batteries were added to the battery bank. In 2016 a small shelter was built for the batteries.

9.3.3. Frequency

Power Heath is visited at every visit at the Heath.

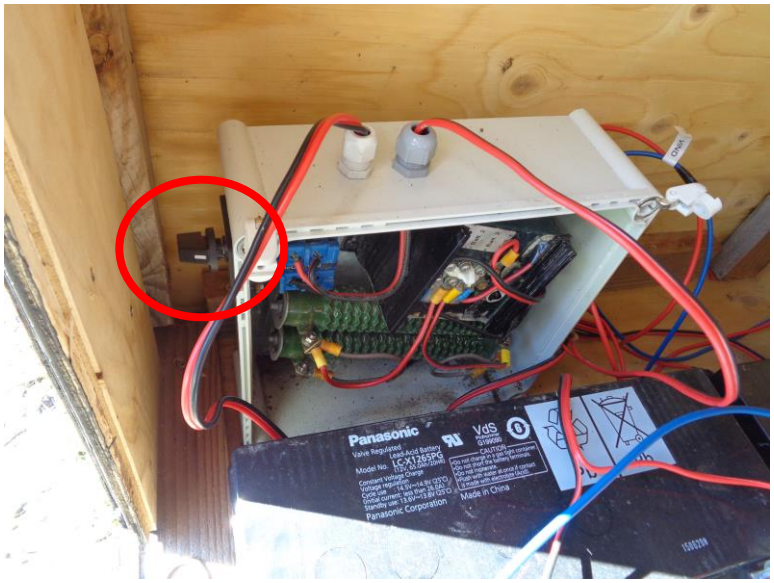
9.3.4. Station check

Write down in the field journal:

- **Voltage:** on the batteries.
- **Sun:** does the sun shine.
- **Wind:** does the wind generator run.
- **Changes:** If you do any changes of the station.

9.3.5. Wind mill

Sometimes in very windy and sunny weather the batteries can be overloaded. In that case they will make a high pitched sound. Then the windmill can be turned off using this button:



9.3.6. Batteries

The battery bank consists of 8 * 100 Ah batteries, 12 V. Each battery weighs 32.5 kg. The voltage on the batteries should be around 12.5-13.5. The batteries are the old ones from Power Fen from 2008.

9.3.7. Power for field tablet

It is possible to charge the field tablet in the Power Heath hut if needed.

9.3.8. Winter

Interact mast and SPA is running through the winter. Both solar panels and wind generators are connected during the winter.

10. End of season

10.1. Shipping

Usually there is a lot of equipment to be send to Denmark every winter. Talk with Birger to find out what to send. Use the Clip-Lok box to send the Methane LGR with Royal Arctic Line. Call +299 349100 for booking or use information from previous bookings to fill out the booking formula here: http://www.ral.dk/bookingcenteret/bookingformular/.
Remember to order a delivery from Aalborg to Copenhagen and a pickup at Asiaq by calling RAL.

- **Methane:** LGR in Zargesbox to Mikhail via Birger for calibration and check.
- **Soil water/river water:** One -18 and one +5 insolated package (find insolation at the workshop and remember to mark the boxes) are sent to Birger with Blue Water Shipping (see section 19.3 for location). For more information call +299 325410. The water samples are brought to the Blue Water office.

Shipping labels is found in the folder:
P:\B53_Nuuk_Basic\b53-06 GeoBasis\MISC\Div\Fragt\Shipping Labels

Previous bookings can be seen in the folder:
P:\B53_Nuuk_Basic\b53-06 GeoBasis\Misc\Div\Fragt\Fragtkvitteringer

The value on all the packages has to be around 1000 kr. and not more than 3999 kr., because then we have to pay taxes.
Remember to write at the label of the Clip-Lok box, that the equipment is only send to Denmark for calibration and that it will be send back to Greenland.
A Clip-Lok box has the dimensions: H = 82 cm, W = 80 cm, L = 120 cm. It will be weighed by RAL.

10.2. Data control

In the field: If possible, all data should be briefly checked in the field or the hut. Check if the time stamp is right, the values look reasonable and if there are any error values (-7999).
During the season: Data should be imported to Wiski and quick-checked as soon as possible after it has been collected; this makes the work after the field season easier and secure that you discover problems as soon as possible.
If some parameters are not yet created in Wiski, they should be. The Asiaq staff can help you with that.
After the field season: The final quality check (QC) of GeoBasis data is not as comprehensive as the QC of ClimateBasis data; however, the GeoBasis data should be compared with similar data from the other stations in Kobbefjord (including 652/653), with the time lapse pictures and with data of previous years. It is of great importance that we don't distribute incorrect data!
The QC is done in Wiski and it is very important that data corrections are well documented with remarks.

Help to QC can be found here: *"F:\Klima_Hydrologi_Miljoe\Procedurer\Datakvalitetssikring\Procedure for quality control - all_english.doc"* and here*: F:\Klima_Hydrologi_Miljoe\Procedurer\Datakvalitetssikring*

When QC is done, it should be uploaded to the GEM dropbox and an email should be send to Jonas Kofoed Rømer.
Data is also sent to Birger.

10.3. Data delivery to the GEM database

Every year data from the GeoBasis stations is delivered to the GEM database. The delivery is done in spring (normally March or May) the following year. This means that data from the season 2016/2017 is delivered in spring 2018. Follow the instructions in *..\..\Datalevering til GEM\Manuals for data delivery* and update the document for each year *..\..\Datalevering til GEM\Manuals for data delivery\Generelt\GEMupload-Notat_KER.docx*.
Note any major problems or changes in the metadata document and send the updated version to Jonas.The metadata document must be saved as a new version each year and placed in the data delivery folder. Always make sure that new routines and procedures are well documented after each field season.

10.4. Field charts

Scan all the field charts or copy them from the field tablet and save them in the right folders at the Asiaq servers.
The paper field charts are stored in the ring folders at the office. From spring 2018 digital field charts at the field tablet can be used instead of paper field charts.
Send the digital field charts to Birger.

10.5. Equipment

Fill out the "Closedown at end of field season" document and store it here: *P:\B53_Nuuk_Basic\b53-06 GeoBasis\Misc\Plans for field work*

Repair broken equipment (often chamber lids from Methane station) and order equipment that we need for next season.

10.6. Year summary

- Make the power point presentation year summary that are found in the field journal folder: *P:\B53_Nuuk_Basic\b53-06 GeoBasis\Misc\Field journal*
  Write down all important changes which have been done for the stations, what is not working and what should be fixed before next season. Send the Power Point document to Birger or present it at the annual GeoBasis meeting in Copenhagen/Roskilde in December/January.
- Update the figures and tables found in the folder: *P:\B53_Nuuk_Basic\b53-06 GeoBasis\Misc\AnnualReport_Cards_Figures* and send them to Birger.

10.7. Field journal

Save the finished field journal as a PDF and send it to Birger and whomever should be interested.

10.8. GeoBasis manual

Update the GeoBasis manual and appendices! Make sure to save the new updated versions also on the field tablet and print new hard copies for the hut and the stations if needed.
The copies at the stations should be laminated!

10.9. Station Sensors

Update the document **Appendix 1 Station sensors**. It is very important that we have an overview of all sensors and serial numbers in the field and for how long they have been used.

11. Office routines

11.1. Introduction

The frequent field work in the GeoBasis program require disciplined office routines in order to organize data, metadata and to plan new field work. This section gives an overview of the GeoBasis office routines at Asiaq.

11.2. Station portfolio

Each of the GeoBasis stations has both a physical portfolio and a computer folder. The physical folder holds general information about the station:

1. General information [Map Coordinates, purpose, establishment dates, communication].
2. Field visits [Field Charts].
3. Map/Drawings [Especially buried installations].
4. Program [current and historic .Cr1-files and the associated .fls-files are located here].
5. Diagram [current and historic wiring diagram of the station].
6. Data check [analysis of data, graphs].
7. Sensors [calibration sheets, serial numbers of current and historic sensors].
8. Miscellaneous.

11.3. Station folder

The computer folders are located on this path: *P:\B53_Nuuk_Basic\b53-06 GeoBasis\GeoBasis Stations\...*

Each station folder has this structure:

1. Raw data [contains raw data]
    - Raw data from the dataloggers are stored in a csv and TOA5. The CSV files are named according to this convention: GBXXIDMMM_YYYY-DOY_YYYY-DOY.dat. The year and day numbers refer to the first and last record of the data file. The file is set to be write protected. It is very important that you name the files the same way as earlier.
2. Diagram/program [copies of current and historic .Cr1-files and .fsl-files]
    - When changing a program on a station it is important to keep record of the files and dates. When retrieving a program from a datalogger it is called: ANK_YYYYMMDD.cr1 When uploading a new program to a datalogger it is called: AFG_YYYYMMDD.cr1.
    - Each uploaded program has a corresponding .fsl file, which describes the headers of the comma-separated array of numbers. (If changes to the output tables are needed, remember to update the .fsl file and the data exchange numbers in the WISKI database.)
    - Also the wiring diagram is associated with the program and it should always be updated. Remember to make a copy when changing the station setup.
3. Print screen
    - Every time data is downloaded, the print screens are saved in this folder.

11.4. Pictures

The pictures from Kobbefjord are stored in the photo database *P:\B53_Nuuk_Basic\b53-06 GeoBasis\Photo database.* Each station has its own folder where pictures from that specific station are saved. Remember to delete bad pictures and turn the pictures the right way when uploading them to the database.

11.5. Data and field charts

11.5.1. WISKI database

Data from some of the stations are stored and edited in the Wiski (W7) database. Importing data to the database via the automatic data importer is relatively simple:

The updated .fsl file is placed in this folder: *\\ASIAQ014\kidsm\input\Campbell1-FSL*

The data file is edited so that its name is accurately the same as the .fsl file ('GB01ID5.dat' corresponds to 'GB01ID5.fsl'). The data files can easily have an extension (normally a date) following an underscore. For instance GB01ID5_20170810.dat can be imported. Remember that Wiski reads CSV format files and not TOA5.

Station	**Status**
M300	Should be added in W7 in 2018, when the station has sensors
M500	All data in the database
M1000	ClimateBasis Station
SoilFen	All data in the database
SoilEmp	All data in the database
SoilEmpSa	All data in the database
Interact Fen	Most of the data in database. New parameters in 2018 should be added
Interact Heath	Data from a period is in the database, data after change in program has to be added

Not all data is quality controlled in W7. Data before 2017 is therefore imported to Wiski from the GEM database and stored in the import time series. These timeseries are quality controlled.

11.5.2. Conversion from binary to CSV or TOA5 files

If the card from a CR1000 has been changed the data should be converted. Help for this can be found in **Appendix 4**.

11.5.3. Update the field tablet time:

Once per week the field tablet time has to be synchronized with WGWT =UCT-3 hours via this home page:

www.worldtimeserver.com/clocks/

11.5.4. Field Charts

Once in a while the Field Charts are collected from Kobbefjord and digitized (values/information from field charts are written in Excel) in the office at Asiaq. The hardcopies of the field charts are stored in a portfolio in the office. It is important that you check that you write in the field charts the same way as the previous years with same units and details – use the previous year as a template.

11.6. Places of interest in Nuuk