# Zackenberg Ecological Research Operations

# GeoBasis

## Guidelines and sampling procedures for the geographical monitoring programme of Zackenberg Basic

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**&**
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**This edition of the GeoBasis Manual**

Please notice that this manual is a preliminary edition. The GeoBasis program is subject to changes and improvements and therefore the manual is continuously under construction. Missing sections and new updates will be implemented in the next edition. Some sections of this manual are based on revised parts of the former Danish version of the GeoBasis Manual, written by Morten Rasch, but as the monitoring programme has been extended during the last years, large parts and sections are new and may still need some editing.

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

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**Acknowledgements**

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GeoBasis

**Front cover illustration**

Photo from early June showing the solar panel rag used to power the Micrometeorological station in the central part of the valley (see Chapter 7, Carbon dioxide-flux monitoring).

**APPENDIX**

# 1 Introduction

## 1.1 The GeoBasis programme

The primary objective of the GeoBasis monitoring programme is to establish a baseline knowledge on the dynamics of fundamental physical parameters within a High Arctic environment. High Arctic landscapes are extremely vulnerable to even small changes in physical conditions and therefore they are sensitive indicators for environmental changes. GeoBasis collect data of hydrological and terrestrial variables including; 1) Snow, ice and permafrost, 2) River water discharge and chemistry, 3) Precipitation and soil water chemistry, 4) Carbon dioxide flux, and 5) Geomorphology. 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. Monitoring was initiated in 1995/1996 and based on the first years experiences additional activities has been and will be incorporated into the programme.

## 1.2 The GeoBasis database

Data from the GeoBasis monitoring programme are published in the "ZERO Annual Report" published by Danish Polarcenter (DPC). After internal secure all validated data from Zackenberg Basic will be available from the internet homepage www.zackenberg.dk. Until the database is ready, data collected by GeoBasis can be ordered from Institute of Geography, University of Copenhagen (cs@geogr.ku.dk) and ClimateBasis data from ASIAQ (dop@asiaq.gl). During the season, data from the climate station are displayed as charts on the notice board in Zackenberg.

Citing of data??

## 1.3 Field season/period

The field season starts when the station opens in late May or early June and ends when the station is left late August or early September. Location of GeoBasis and ClimateBasis plots, referred to in the manual is given in the map (Fig. 1). More detailed maps and UTM coordinates are given in the respective chapters and in App 4.

## 1.4 Daily Journal

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

- Work carried out
- Weather report (generally, clouds, precipitation, wind, fog)
- Condition of the Zackenberg river (sediment, colour/visibility, level, snow/ice drift)
- Snow cover distribution in the valley and on the slopes
- Condition and distribution of the sea ice and fjord ice
- Fill out the worksheet "Statistic observations Zackenberg" (AppX)

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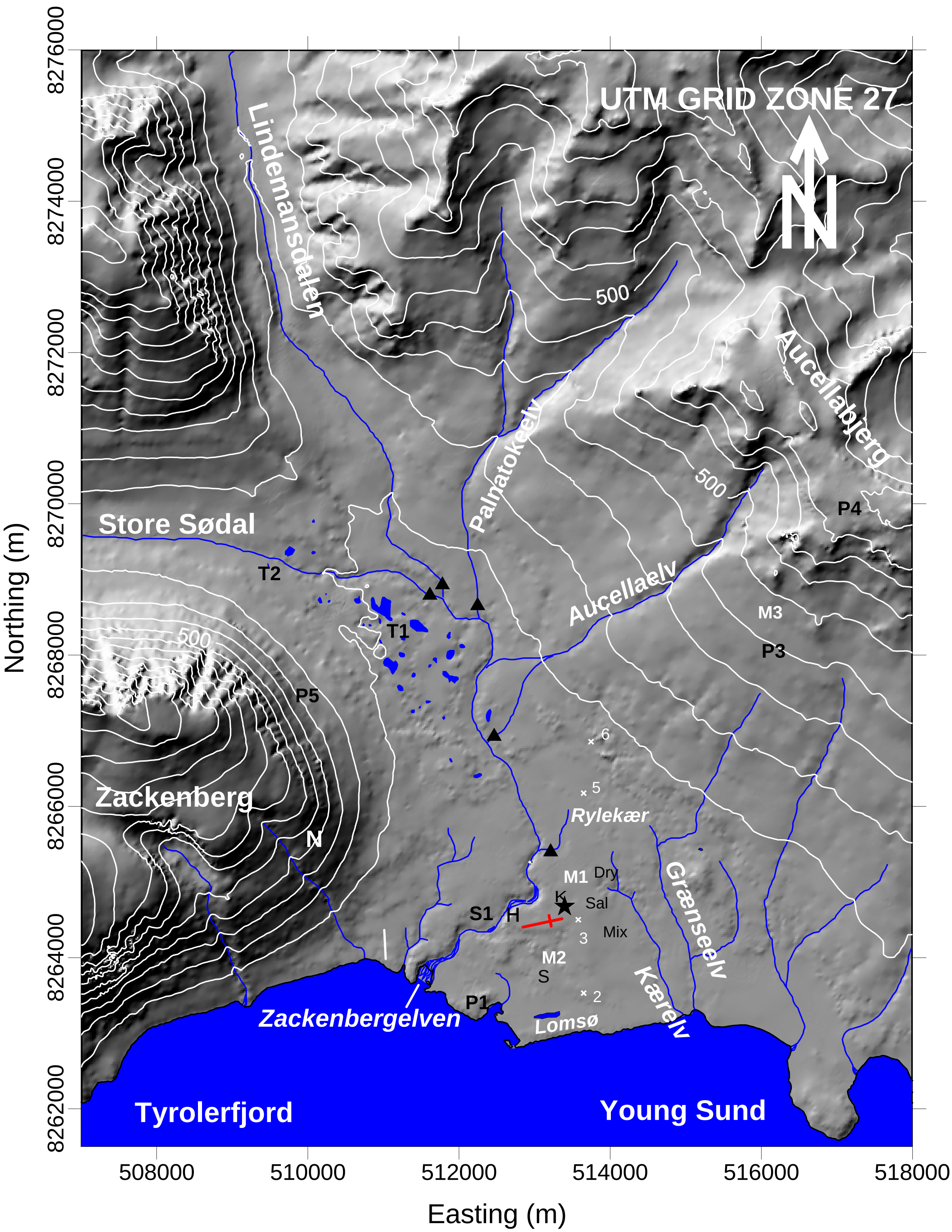



**Fig 1** Map of GeoBasis and ClimateBasis plots referred to in the manual. The climate station is marked by an asterix. H= Hydrometric station. M1= Micrometeorological station. M2 and M3= Snow monitoring and micrometeorological stations Triangles = water sample sites at the tributaries to Zackenbergelven. N = Nansenblokken. K2, S2, Dry, Sal, and Mix = Soil water sites. P1, P3, P4, P5, S1, T1 and T2 = TinyTag temperature sites. Small crosses (x) = Snow stakes 2, 3, 5 and 6.

# 2. Snow and permafrost monitoring

Snow depth and snow cover are among the key parameters in the control of climate and ecosystem processes characterizing the Arctic. As most of the precipitation in Zackenberg fall as snow it plays a major role in the hydrological system. The seasonal and spatial variation in snow cover also significant affects distribution of vegetation and length of the growing season, which indirectly affects the production of greenhousegasses such as carbon dioxide ($CO_2$) and methane ($CH_4$).

**Parameters to be measured**

Snow depth
Snow density and snow water equivalent (SWE)
Snow cover and distribution
Snow cover depletion
Active layer depth
Temperature in snow, ground, air and water

## 2.1 Snow depth

Snow depth are measured continously at three permanent automatic stations (st. 644, M2, M3) and manually in two gridnets (ZC-1 and ZC-2) and at four stakes/poles describing a transect in the valley from the coast to the morraine hills (St 2, St 3, St 5, St 6).

### 2.1.1 Automatic snow depth measurements

The permanent automatic stations measure distance to the snow/soil surface from a fixed point (using a Sonic Range Sensor), soilsurface temperature, and air temperature. Air temperature is used to calibrate the Sonic Range Sensor.

**Fig 2.1** Snow depth mast at the Climate Station

**Location**

Location of the sites are shown in Fig 1.1 and Fig 2.1-2.3.

*Climate Station snow mast (st. 644)*

Located 30 m north of the climate station in the *Cassiope* heath right north of the eastern end of the landing strip. Near the gridpoint (X,Y) in ZC-1
UTM: 8264774 mN, 513380 mE
Elevation: 45 m a.s.l.
Operation: 1997-
Instrumentation of the mast: Table 1, App3.

**Fig 2.2** Micrometeorological station M2 in ZeroCalm-2. Looking west, towards Zackenberg.

*Micrometeorological station (M2)*

Located on a south facing slope in the ZEROCALM-2 grid, approximately 200 m south of the runway. The mast is situated on the boarder between an upper zone of *Cassiope* and lower zone of *Salix* vegetation.
UTM: 8264501 mN, 512748 mE.
Elevation: 17 m a.s.l.
Operation: 2003-
Instrumentation of the mast: Table 2, App 3

*Micrometeorological station (M3)*
Located on a gently south-west facing slope halfway up Aucella. Approximately 100 m north of this station you find point 100 and 101 on the ZERO-line. The dominating vegetation is *Salix*
UTM-coordinates: 8268250 mN, 516126 mE.
Elevation: 410 m a.s.l.
Operation: 2003-
Instrumentation of the mast: Table 3, App.3

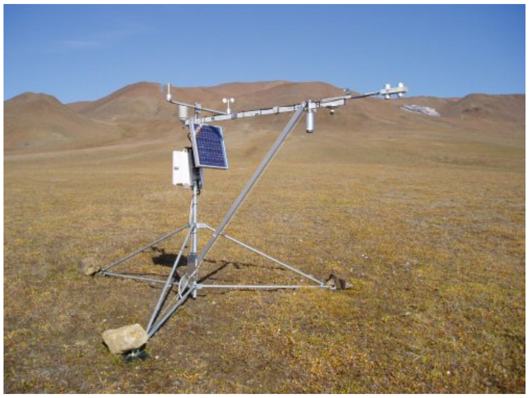


**Fig 2.3** Micrometeorological station M3. Looking east towards the top of Aucella.

**Data storing and power supply**
Distance from the sensor to the surface is logged every third hour at st.644 and recorded on a datalogger (CR500) and on a memory card (CSM1). At M2 and M3 the snow depth is logged every six hours and recorded in a datalogger (CR10X) and stored in a storage module (SM4M). The stations are powered by batteries charged by solar panels. Batteries and dataloggers are placed inside the box mounted on the mast.

**Frequency**
Data from the snow depth masts are offloaded immediately/soon after arrival to Zackenberg and when the snow has disappeared (Field programme, App. 1). Leave a storage module in the logger even after the snow has disappeared as other parameters are still being logged.

<u>**Notice**: Keep walking around the masts to an absolute minimum. Use skies or snowshoes to minimize impact on the snow around and underneath the sensor as it influences the melt rate.</u>

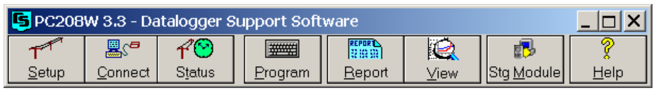
**Procedure for offloading data from the Climate Station snow mast st. 644**
Go to the snow mast (st 644). Measure the distance from the sensor (lower point) to the snow/soil surface using a folding rule. Open the white plastic box and remove the memory card from the card writer. If light is flashing, wait a few seconds before removing the memory card as light indicates that data are transferred at that moment. Record date and time for removal of memory card.

Bring the memory card back to the Station.

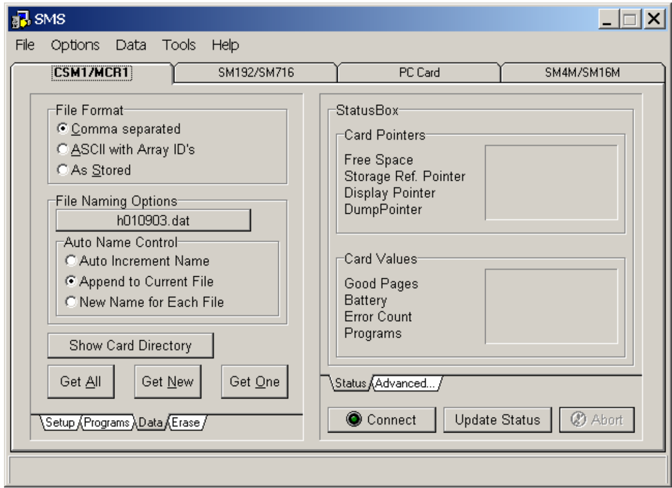
Insert the memory card in the CSM-1 card reader connected to the peripheral port on the SC532 interface (a little gray box which must be connected to a 9 V battery/transformer or to the power outlet)

Connect the SC532 interface to the computer/laptop COM-port by a RS232 cable (gray cable with a 9 pin stick in one end and a 25 pin stick in the other end).

Turn on the computer and choose the Campbell software program “PC208w”.




- From the main menu choose [Stg module].




- On the next menu choose CSM1.
- Press [Connect] and the computer start communicating with the memory card.
- Choose [Data] in the lower left side of the screen.
- Write a file name after the principle sYYMMDD (s=snow, YY = year, MM = month and DD=day) and choose a directory.
- Press [Append to current file] and [Get New].
- After data retrieval press [Disconnect]. Remove the memory card and bring it back to the Climate Station and re-insert card in the card writer.

**Notice:** Data from the station are stored in the datalogger when the memory card is decoupled and will be transferred as soon as the card is reconnected.

**Input of data into the local database**
Move the retrieved data file to the GeoBasis directory **(GeoBasis\climate station\snow\filename**). Open the file and check that the last logged value corresponds to the actual day of year (DOY) and time for removal of the storage module (DOY calendar, App 5). If not -please contact ASIAQ.

**Notice**: Use the software programs “Surpher” or “Grapher” when opening the files as these programs are better than Excel in handling large time series.

**Procedure for offloading data from the micrometeorological stations M2 and M3**
Off loading data from the M2 and M3 can be done direct in the field or the storage modules can be brought back to the station for retrieval of data. In the field the latest data can be retrieved direct from the datalogger (the datalogger holds up to one month of data at these stations) but if data from a longer period are to be retrieved the storage module must be off loaded.

**Equipment to be used**

Laptop computer
Screw driver
Serial cable (cable with a 9 pin stick in both ends)
SC532 interface (a little gray box which can be connected to the power outlet. For field use a 9V battery/transformer must be used)
RS232 cable (gray cable with a 9 pin stick in one end and a 25 pin stick in the other end)

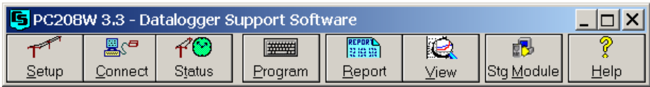
**Offload data from storage module in the field**

- Go to the station. Undo the top and bottom screws on the white box mounted on the mast and open it.

- Disconnct the storage module from the datalogger. Record date and time for removal.

- Connect the storage module to the peripheral port on the SC532 interface by a SC12 cable (blue cable with 9 pin stick in both ends). Power the SC532 interface by the 9V battery transformer and connect it to the computer/laptop COM-port by a RS232 cable (gray cable with a 9 pin stick in one end and a 25 pin stick in the other end).

- Turn on the computer and choose the Campbell software program “PC208w”.




- From the main menu choose [Stg module].

- On the next menu choose [SM4M/SM16M].

- Press [connect] and the computer starts communicating with the storage module.

- Choose [Data] in the lower left side of the screen.

- Write a file name after the principle xxYYMMDD (xx= M2 or M3, YY = year, MM = month and DD=day) and choose a directory.

- Press [Append to current file] and [Get New]

- After data retrieval press [Disconnect] and reinsert the storage module in the datalogger

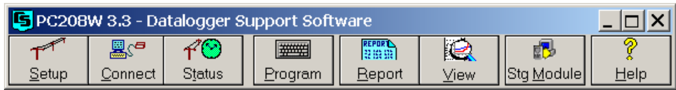
**Offload data directly from datalogger in the field**

- Only laptop computer, screw driver and serial cable (cable with a 9 pin stick in both ends) are needed

- Go to the station. Undo the top and bottom screws on the white box mounted on the mast and open it.

- Disconnect the cable from the storagemodule into the datalogger. Connect the Serial cable to the datalogger and to the computer COM-port.

- Turn on the computer and choose the Campbell software program "PC208w".




- From the main menu choose [Connect].

- Compare datalogger time and actual time (shown in the upper right corner). Record any drift.

- On the next menu choose……..Get all/Get new

- Write a file name after the principle xxYYMMDD (xx= M2 or M3, YY = year, MM = month and DD=day) and choose a directory.

- After data retrieval press [Disconnect]. Remove the cable. Close the white box.

**Input of data into the local database**

Move the retrieved data file to the GeoBasis directory **(GeoBasis\Micrometeorological station\ M2 (M3)\filename)**. Open the file and check that the last logged value corresponds to the actual day of year (DOY) and time for removal of the storage module (DOY-calendar, App 5). If not -please contact Birger Ulf Hansen.

**Maintenance**

- Wires from the mast tent to loosen during winter months. Strengthen the wires to keep the station in a vertical position. Vertical distance from the SR50 sensor to the point/target on the ground is 1.67 m at the snow mast (st 644), 2.47 m at station M2 and 1.88 m at station M3.

- Check battery status on the storage module. Batteries in storage modules should be changed every ??? year. Write year of battery change on the module.

- Before the stations are left, make sure that there is enough free space on the storage modules. If necessary, erase data from the storage module. Use the PC208w program. Choose [storage module] and press [Erase] on the menu. From the erase menu choose [Erase Data]. This option erases all data but restores any programs on the storage module. The storage module can be left in either "Ring mode" or "Stop mode". Leaving the storage module in "Ring mode" will result in over writing of existing data if the storage module runs out of space whereas in "Stop mode" the storage module will stop saving data when the storage module is full.

- For maintenance of the SR50 sensor, see the SR50 Operators Manual

**Troubleshooting**

- User Guides and operator manuals for various sensors, dataloggers, storage modules and support software are collected in house number four in the GeoBasis library and in the GeoBasis office in Copenhagen.

- Always check the power supply. Check voltage on the batteries (Most batteries are 12 V).

- Check that the cables are connected in accordance with the wiring diagram and that no cables are loose in the datalogger ports.

- Check that the time is correct on datalogger and on the computer. The time in Zackenberg is 2 hours behind Denmark and one hour behind GMT. All dataloggers run local Zackenberg time.

- If the power for any reason has been cut, it might be nescesarry to re-install the program on the datalogger. This can be done via computer or via storage module. Campbell CR10X program for station M2 and M3 are located in the GeoBasis directory:
  **(GeoBasis\Micrometeorological station\M2\program\M2.dld)**
  **(GeoBasis\Climate stations\M3\program\M3.dld).**

- ASIAQ programs are located in the GeoBasis directory:
  **(GeoBasis\ASIAQ\Zackenberg\Programs\)**

- Procedure for installing programme in the datalogger. Turn on the computer and choose the Campbell software program “PC208w” on the desk. Press [connect] – specify station or datalogger type – [connect] - [asscociate dld.program] – [send]

## 2.1.2 Manual snow depth measurements

Snow depths are measured manually by probing within the valley. This is done in order to extend the number of point measurements for a better coverage of the spatial variability in the snow cover.

**Frequency**

Snow depth surveys are performed as soon as possible after arrival to get the end of vinter snow accumulation. Preferrably, the measurements should be performed before the snow cover become isothermal and starts to rapidly melt.

**Location**

Snow depths are measured at some fixed positions marked by stakes/poles within the valley, at all the soil water sites and near the permanent snow depth masts (M2, M3, St. 644) to be able to calibrate the automatically collected data. For spatial variability snow depth is also measured in the two grids ZEROCALM-1 and ZEROCALM-2 with 121 and 208 points, respectively. Positions of all sites are given in Field chart 1 (App 2) and in Fig 2.4

*Stake 2*

Located c.1 km east of ZC-2 at the end of a gentle slope. Snow tends to accumulate at this

site. It is an area with snow bed vegetation.
The stake was established in 2001.
UTM: 8263902 mN, 513648 mE
Elevation: app.12 m a.s.l.

*Stake 3*
Located about 30 m SE of the climate station in a snow bed vegetation. The stake was established in 2001.
UTM: 8264686 mN, 513471 mE
Elevation: 39 m a.s.l.

*Stake 5*
Located in Rylekærene in an Eriopherum triste fen area. The stake was established in 2002.
UTM: 8266089 mN, 513538 mE
Elevation: 50 m a.s.l.

*Stake 6*
Located c. 2 km northeast of stake 5 at the foot of the morraine hills. It is an area of fen/grassland vegetation. The stake was established in 2002.
UTM: 8267092 mN, 513641 mE
Elevation: 60 m a.s.l.

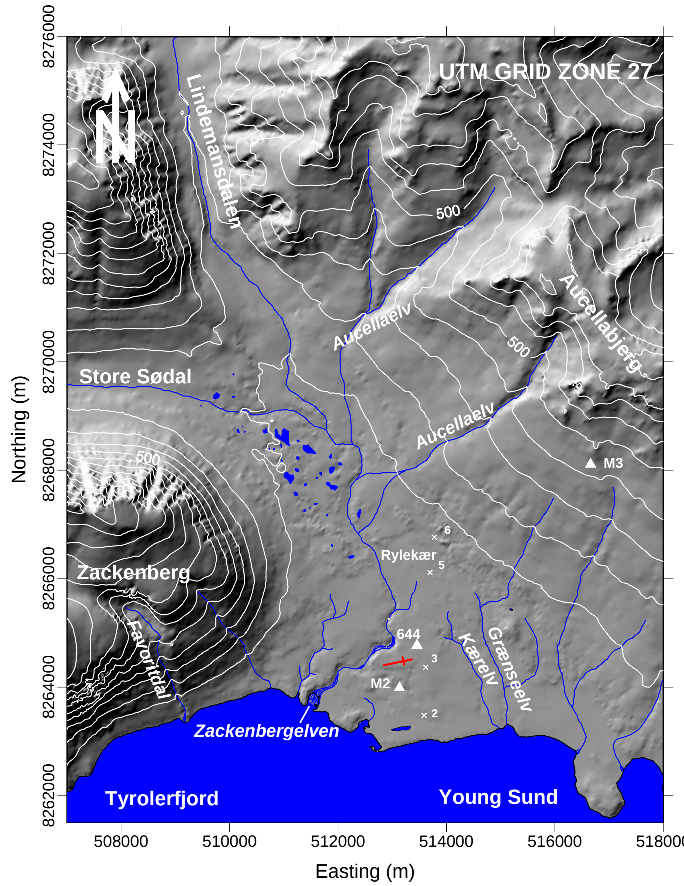



**Fig 2.4** Location of snow depth stations and stakes

*ZEROCALM-1 (ZC-1)*
Located right north of the climate station on a horizontal and well-drained *Cassiope* heath. The site consist of 121 measuring points in a 100 m x 100 m grid (11 almost N-S oriented rows each with 11 points). There are 10 m between every point. Every corner of the grid is marked by orange traffic poles. Points along the edge of the grid are marked by orange stones while all other points are marked by white stones.

| | | |
|---|---|---|
| UTM: | NW-corner: | 8264856 mN, 513363 mE |
| | NE-corner: | 8264847 mN, 513461 mE |
| | SW-corner: | 8264758 mN, 513347 mE |
| | SE-corner: | 8264748 mN, 513446 mE |

Elevation: 45 m a.s.l.

*ZEROCALM-2 (ZC-2)*
Located c. 400 m south of the runway on a south facing slope at an elevation of 11-22 m a.s.l. Vegetation change from dry *dryas* heath at the upper end to a waterlogged *Eriophorum* fen in the lower end. The site consist of 208 measuring points in a 120 m x 150 m grid (16 almost N-S oriented rows each with 13 points). There are 10 m between every point. Every corner of the grid is marked by green poles. Points along the edge of the grid are marked by orange stones while all other points are marked by white stones.

| | | |
|---|---|---|
| UTM: | NW-corner: | 8264083 mN, 513025 mE |
| | NE-corner: | 8264033 mN, 513167 mE |
| | SW-corner: | 8263970 mN, 512985 mE |

SE-corner: 8263920 mN, 513127 mE
Elevation: 13-22 m a.s.l.

**Fig 2.5** Magnaprobe in use. The metal rod is pushed into the snow until refusal. The rod is connected to a CR10 datalogger. A depth reading is made when you pres the thumb switch on the handle. A GPS position is recorded as well.

**Equipment to be used**
Avalanche probe (3 m)
Snow GPS Magnaprobe (useful for snow depth up to 1.10 m, remember to charge batteries)
GPS-Magnaprobe operating instructions
Folding rule
Measuring tape
Field chart 1 (App 2)
GPS
Skies/Snowshooes
Digital camera

**Procedure for manual snow depth measurements**

- Go to the survey site. Use map and UTM coordinates given on the field chart. <u>Keep walking around the site to a minimum to prevent impact on the melting rate.</u>

- Record date, time and remarks about the snow surface condition (smoothness, dust deposits, colour, tracks etc…) on the field chart

- Push the Magna probe vertically into the snow until refusal, presumably by the ground or ice surface (see Fig 2.5). The white basket floats on the snow surface. Press the thumb switch on the hanndle and make a reading of the snow depth (distance from the tip of the rod to the basket). The depth and a GPS position are recorded in the CR10x datalogger when the reading is made. Make sure to penetrate ice lenses/layers in the snow pack.

- If the snow is more than one meter deep, the 3 m long avalanche probe must be used and the snow depth recorded in the field chart

- 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/lins.

- Take a digital photo of the site.

**Procedure for manual snow depth measurements at the gridnet**

- Go to the grid. Localize the four corners. Only the four poles marking the corners of the grid net can be used for location as individual gridmarkers are likely to be covered in snow.

- Try to establish the gridpoints. Use extra ranging poles to temporarily mark the end points of the lines. Walk two persons with a tape measurer between you and head towards the end of the line. Probe/measure the snow depth for every 10 meter, observing you are in the line.

<u>Notice: No need for very exact locations of the grid points, as the snow cover will presumably be more or less evenly distributed locally.</u>

**Input of data into the local database**
Data from the field chart are stored in the GeoBasis directory **(Geobasis/Snow/manual/sd DDMMYY)**. sd=snow depth, DD=day, MM=month, YY=year. Data from the CR10x datalogger must be off loaded according to the instructions for "dumping and processing" data in the MagnaProbe manual. Data from the grids are written in the ZC-1 and ZC-2 template, respectively (Geobasis /manual/templates/ZC-1 or ZC-2) and stored in the GeoBasis directory **(Geobasis/Snow/manual/ZC-X sdDDMMYY).**

## 2.2 Snow density, snow water equivalent (SWE)

Snow density and snow water equivalent (SWE) at the end of winter accumulation is an important input to the water balance of the area and for correction of the solid precipitation measured in the precipitation gauge. Snow water equivalent are measured manually at some fixed positions marked by stakes/poles within the valley, near the permanent stations M1, M2, M3, St 644 and at all the soil water sites.

**Frequency**
Preferably before melting takes place for an end of winter SWE, and periodic measurements during the ablation period from one site near the climate station.

**Location**
Snow water equivalent are measured manually at the fixed positions within the valley and adjacent to all the soil water sites. Positions and descriptions of all sites are given in the field chart and in Field chart 2 (App2). It is of great importance, that samples are collected in order not to affect the snow around the permanent stations. Therfore, samples should be taken at least 10 m away from the automatic stations in a place representative of the conditions in the area. In ZEROCALM-2 samples should be taken where the seasonal snow patch is deep c. 10 m southwest of M2. At the soil water sites samples should be taken downstream from the site.

**Equipment to be used**

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

**Procedure for determination of snow water equivalent (SWE)**

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

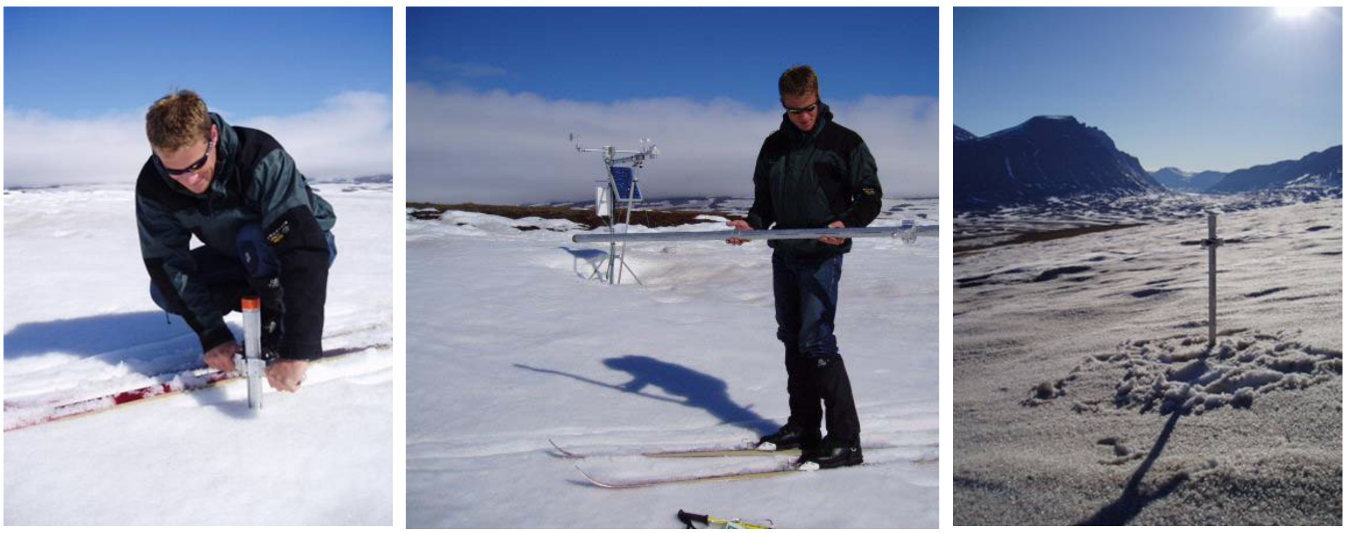


**Fig 2.6** Snow sampling tube in use. Skaf et billede hvor der vejes, så man kan se den hænger frit

- Go to the site. Find an undisturbed snow surface near the pole/stake. Record the UTM position from the GPS

- Assemple sampling tube screwing tube sections together handtight. Make sure numbers on the scale run consequently. Before taking a sample, check the tube for cleanliness (no snow inside the tube).

- 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.

- Turn tube at least one turn to right to cut core loose from earth. Carefully raise tube, look through slots, and 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 isn´t, retake the sample.

- Inspect cutter end of tube for dirt or litter. Use a knife or a can opener 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.

- Carefully balance the the sampling tube containing the core on the weighing cradle. Never hold the weighing scale with hand around barrel. Suspend it like a pendulum from a ski pole. If windy, point the tube into the wind. Record the weight in the field chart.

- Remove the snow core from the tube by gently tapping the tube against a rubber pad on the ski.

- Weigh the empty sampling tube. If using the driving wrench, be sure to leave it attached when weighing the empty tube and when weighing the tube and core of snow. Check weight of empty tube at least every fifth sample

**Notice**: A well siliconed or waxed tube helps in removing the snow core and the tubes screw together without binding.

**Input of data into the local database**
Data are stored in the GeoBasis directory **(Geobasis/Snow/manual/SWEDDMMYY)**. SWE=snow water equivalent, DD=day, MM=month, YY=year.

**Maintenance**
- Keep the sampling tubes clean and covered inside with a thin coating of spray silicone or wax.

**Troubleshooting**
- If snow melts and freezes inside the tubes, it is probably because the tube is above freezing and the snow below freezing temperature. Cool the tube by setting it in the shade or burying it in the snow. Another help could be to take samples early in the morning or late in the evening when it is cool

## 2.3 Snow cover and depletion
Digital images of the main study area in Zackenbergdalen is used to monitor spatial and temporal snow cover distribution and to model depletion curves for snow in the valley.

### 2.3.1 Automatic snow cover monitoring
Digital cameras in waterproof boxes are mounted on a permanent platform where each camera box is secured in a fixed position and orientation (Fig. 2.7). There is room for five camera boxes on the platform. External power is supplied from four 12 V batteries charged by solar panels.

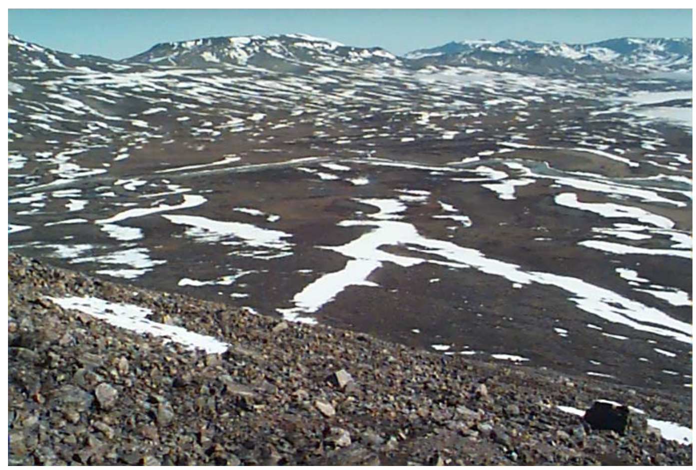
**Fig 2.7** The fixed installation on top of Nansenblokken 480 m a.s.l. (left). Position of Nansenblokken on the eastern slope of Zackenberg (right).

**Location**

Digital images are taken from the top of Nansenblokken, a prominent rock on the east slope of Zackenberg.
UTM: 510992 mE, 8265315 mN.
Elevation: 480 m a.s.l.

*Camera 1:*
Covers the southern part of the valley and Young Sund.
Instrumentation: Kodak, DC-50. Replaced by a Kodak RDC 365 (10 June 2004).
Operation: since 1999
Memory card: 256 MB Secure Digital card

*Camera 2:*
Covers the main part of the study area in the valley.
Instrumentation: Kodak, DC-50.
Operation: since1997
Memory card: Compact Flash card 48 MB



*Camera 3:*
Covers the most northern part of the valley
Instrumentation: Kodak, DC-120.
Operation: since 2001
Memory card: Compact Flash card 128 MB

**Frequency of sampling**
Digital pictures are taken every day at 1:20 pm (solar noon). Data are off loaded from the cameras soon after arrival to Zackenberg and frequently during the season (Field programme, App. 1).

**Equipment to be used**
Laptop computer with USB-reader and adapters for reading memory cards
Latest version of Photo Enhancer software (KODAK)
Voltage meter
Screwdriver
Watch
User manual for each camera
Field chart 3, App.2
Spare 12 V battery

**Procedure for offloading cameraes**

- Open the camera box by undoing the four screws.
- Write down the time displayed on the timer and the actual time and day for off loading the memorycard.
- Pull the eject button and remove the memory card. Make sure not to eject it when the picture is taken 1:20 pm.
- Insert the memory card in the computer PCMCIA port or in the card reader.
- Move all data from the memory card to the computer harddisc. Files on the card should only be deleted if the remaining free space on the card is low. All data from camera 1 are moved to a folder called: Cam1 DDMMYY:HHMM.
- Record the number of pictures off loaded and check that the number of pictures since last off loading matches the actual number of days since last sampling.
- Record the external battery power using the voltage meter. Voltage must be more than 12 V
- Re-insert the card in the camera. Make sure that the orientation of the card is right. Press to ensure good connection.
- Make sure that the timer in the box is turned “off” before you leave the camera (cam. 2 and 3).
- Especially for camera 1: Make sure that no wires/cables or any other items are left on top of the battery in the box, as these can press the ON-button on the control panel when the box is closed. This will turn the camera on and drain the battery in less than 2 days.
- Before you close the waterproof box securely, make sure that there is a bag of descicant (Silica Gel) in the box and that the window infront of the lens is clear.

- The same procedure is used for camera 2 and 3. All data from camera 2 are moved to a folder called Cam2 DDMMYY:HHMM and data from camera 3 are moved to a folder called Cam3 DDMMYY:HHMM.

**Settings:** *Camera:* Always make sure that auto focus is disabled and the flash light disabled or the flash is covered. *Timer:* Timer must be switched off when the camera is left (“Off” in the display)**.** Timer is programmed to switch on every day at 1:20 pm and switch off every day at 1:21 pm

**Input of data into the local database**
View images in PhotoEnhancer or another photo software program. Take back-up of all photos. Name photos after the system: camX YEAR XXXX DOY XXX (ex. Cam1YEAR2002DOY155 ~ picture from camera 1 taken 4 June 2002). Images are saved in the GeoBasis directory (GeoBasis \Photomonitoring\Automatic\Camera 1). After renaming the pictures, they are saved as BMP files as well as KDC files. Make a new back up of renamed pictures. Always keep a back up of the raw data with original filenames.

**Laboratory work**
Images are transformed into digital orthophotos which are used for snow cover mapping –separate manual from JH

**Maintenance**

- Batteries must be replaced every ??? year.

**Trouble shooting**

- Always check the power supply if cameras have stopped taking pictures.
- Check that the memory card has enough free space.
- Consult the User Guide for camera and timer.
- If problems can not be solved at the site undo the box and bring the camera to the station.

**NDVI-camera**
During the summer season a NDVI-camera is mounted in one of the boxes. At the first visit to Nansenblokken bring the NDVI-camera. A separate manual exist for this camera. Mount the camera on the steel plate in the box and secure it in a fixed position. Adjust the focus lens so that the mark on the lens is next to the mark on the camera house. To be continued.

## 2.3.2 Manual snow cover monitoring

Digital images of the main study area in Zackenbergdalen are also captured manually to ensure high resolution photos on certain days during the snow melt period.

**Location**
Pictures are taken from the top of Nansenblokken on the east slope of Zackenbergfjeldet, where also the automatic snow cameras are mounted.
UTM: 510992 m E, 8265315 m N.

Elevation: 480 m a.s.l.

**Frequency**
On days with fine weather (no clouds or fog in the photo area) around 1 June, 10 June, 20 June and 30 June, respectively. On sunny days, pictures must be taken in the afternoon (> 16 pm) to prevent direct sunlight into the camera. It takes about 1-2 hours to walk to the photo site.

**Equipment to be used**
Nikon F50 camera marked “Snefotos” and with the 35-80 zoom length marked with a cross on the inner ring (important, since only this camera has been measured for distortion)
64 ASA colour slide films

**Procedure for taking photos**

- Activate the automatic photo dating system (put it in the order day, month, year) on the back of the camera.

- Set the focusing on manual (M), turn the focus to maximum distance and turn the zoom to maximum wide angle (35 mm) - and make sure that it stays there!

- Set the photo programme in "Landscape" mode.

- Take three photos of the valley starting from the south with the Simpson hut at the right edge of the frame, the next from the research station northwards and the last covering the leftmost visible part of the slopes of Aucellabjerg (see sample Fig 2.8). Keep the mountains in the horizon in the absolute uppermost part of the pictures, so that even the slope of Zackenberg below you is covered by the photos.

- Turn the zoom to maximum magnification (80 mm) and repeat the procedure, this time with five photos covering only the main census area (the horizon must still be included as photos have to be rectified).

- Repeat the process preferably with another film in the camera.

| | | |
|---|---|---|
| | | |

**Fig 2.8**. Billeder fra JH

**Input of data into local data base**
Images are transformed into digital orthophotos which are used for snow cover mapping –separate manual from JH.

# 2.4 Monitoring development of the active layer

The active layer is the part of the soil that is object to seasonally thawing and freezing. Thickness of the active layer varies from year to year, depending on factors as ambient air temperature, vegetation, drainage, soil type, water content, snow cover, degree and orientation of slope.

**Location of sites**

Depth of active layer, are measured at two sites, ZEROCALM-1 and ZEROCALM-2.

*ZEROCALM-1 (ZC-1)*

Located right north of the climate station on a horizontal and well-drained *Cassiope* heath. The site consist of 121 measuring points in a 100m x 100 m grid (11 almost N-S oriented rows each with 11 points). There are 10 m between every point. Every corner of the grid is marked by orange traffic poles. Points along the edge of the grid are marked by orange stones while all other points are marked by white stones.

| | | |
|---|---|---|
| UTM: | NW-corner: | 8264856 mN, 513363 mE |
| | NE-corner: | 8264847 mN, 513461 mE |
| | SW-corner: | 8264758 mN, 513347 mE |
| | SE-corner: | 8264748 mN, 513446 mE |

Elevation: 45 m a.s.l.

*ZEROCALM-2 (ZC-2)*

Located c. 400 m south of the runway on a south facing slope at an elevation of 11-22 m a.s.l. Vegetation change from dry *dryas* heath at the upper end to a waterlogged *Eriophorum* fen in the lower end. The site consist of 208 measuring points in a 120 m x 150 m grid (16 almost N-S oriented rows each with 13 points). There are 10 m between every point. Every corner of the grid is marked by green poles. Points along the edge of the grid are marked by orange stones while all other points are marked by white stones.

| | | |
|---|---|---|
| UTM: | NW-corner: | 8264083 mN, 513025 mE |
| | NE-corner: | 8264033 mN, 513167 mE |
| | SW-corner: | 8263970 mN, 512985 mE |
| | SE-corner: | 8263920 mN, 513127 mE |

Elevation: 11-22 m a.s.l.

**Fig 2.9.** Location of the two ZEROCALM sites ZC-1 and ZC-2 (left). Photo monitoring point at ZC-2. Looking at ZC-2 from the tripod in the south east corner of the grid (right).

**Frequency**
Measurements are made as soon as one point in the grid is free of snow. Repeat measurements on a weekly basis until the average thickness for the entire grid is about 35 cm. During the rest of the season measurements are performed every second week (Field programme, App. 1). The last measurement is made just before the station is left in late august.

**Equipment to be used**
Stainless steel rod/probe with centimeter graduation and handle (1.2 m long)
Field chart 4 and 5, App.3
Digital camera

**Procedure for active layer measurments**

- Start in one of the corners in the gridnet. Make sure orientation of the field chart is right compared to the grid.
- Press the steel rod vertically down in the ground 5-10 cm north of the painted stone marking the gridpoint.
- When the tip of the rod, touch the frozen surface a finger is placed on the rod at the soil surface. Pull up the rod and read the depth on the centimeter division.
- Note the depth in the field chart. It is important that all measurements are made to the soil surface and not the vegetation surface. Specially, in the wet part of ZC-2 where water is standing on the ground and vegetation is dense it can be difficult to determine the soil surface. Press your fingers all the way down along the rod until you feel resistance.
- Take two digital photos from the tripod in the southwest-corner of the grid in order to cover the snow patch and the east facing slope of Zackenberg (Fig XX for an example).

**Maintenance**

- Birds and musk oxen are able to move the stones. Make sure that stones are in the right positions and if necessary, reestablish the grid.

**Input of data into the local database**
Values from the field chart must be written in the templates ZC-1 and ZC-2, respectively **(GeoBasis/manual/templates/ZC-1 or ZC-2)** and stored in the GeoBasis directory **(GeoBasis/ZEROCALM/Active layer/ZC-1 or ZC-2).**

**Notice:** Check that there is consistency for each point and that the active layer increases or stays the same during the summer. A sudden decrease will only be possible when freeze back of the active layer starts. A sudden lower active layer depth could be caused by hitting a stone. If the measurement is not performed at the exact same spot every time the surface relief can cause variation in depth.

By the end of the season data are reported to CALM (Circumpolar Active Layer Monitoring programme under ITEX (International Tundra Experiment) and IPA (International Permafrost Association). Grid nodes are numbered 1-121 and 1-208 beginning in the northwest corner and reading down the rows as you would read text. Thus the last node 121 or 208 is in the southeast corner. Send the data as Excel files to CALM@uc.edu for archiving.

**Contact:**
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University of Cincinatti
Cincinatti, OHIO 45221-0131
E-mail: Kenneth.Hinkel@uc.edu

**New contact from 2004:**
The recently funded CALM-II program is operating at the University of Delaware.
I forwarded the data to Kolia Shiklomanov and Fritz Nelson.

## 2.5 Temperature in snow, ground, air and water

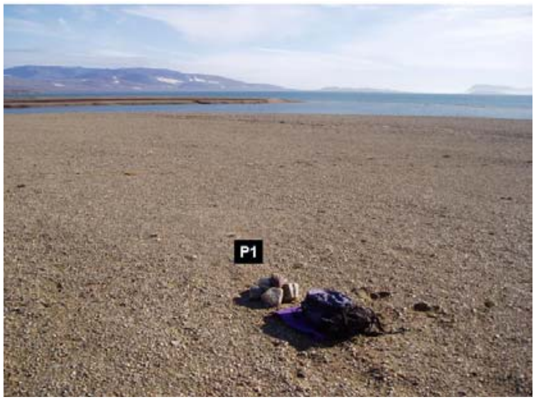
Temperature is monitored at various locations at different elevations within the study area. Small dataloggers are placed in geomorphological settings of interest such as ponds, snow patches and in the ground. Vertical temperature profiles within the active layer describe the temperature regime at different soil types in a transect from sea level to the top of Aucella. At various sites the air temperature near terrain is monitored as well

**Location and description of sites**

All tinytag locations are plotted on Fig 1.1 and a short description given here

*P1*

Eastern part of a gravel plateau south of the Zackenberg station. Close to the coast south of the old delta and east of the Zackenberg river mouth. P1 is located c. 20 m west of site for ice vedge monitoring.
Subject: Active layer temperature
UTM: 512388 m E, 8263490 m N
Elevation: 20 m a.s.l.
Installation depth: 0, 10, 50, 118 cm
Operation period: 1995-

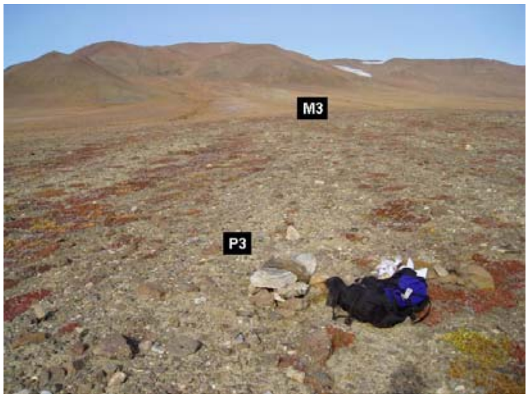



*P2*

In an ice wedge c. 70 m south of the Zackenberg Station at the end of a south facing slope. Close to the site for ice wedge monitoring. Subject: Temperature of active layer in an ice wedge
UTM: 512713 m E, 8264257 mN
Elevation: 23 m a.s.l.
Installation depth: 0, 10, 70, 155 cm
Operation period: 1995-2000

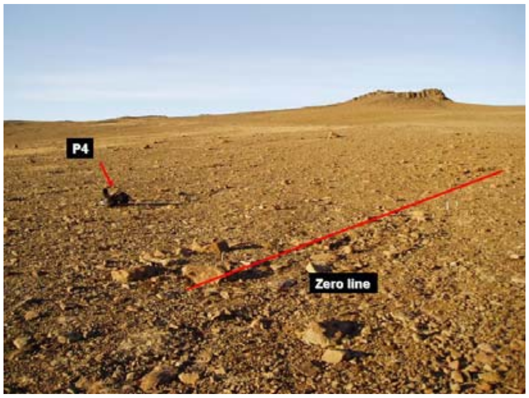

*P3*

South west facing slope of Aucella c. 30 m northwest of the ZERO-line
Subject: Active layer temperature
UTM: 515917 m E, 8268224 m N
Elevation: c. 400 m a.s.l.



Installation depth: 0, 10, 66 cm
Operation period: 1995-

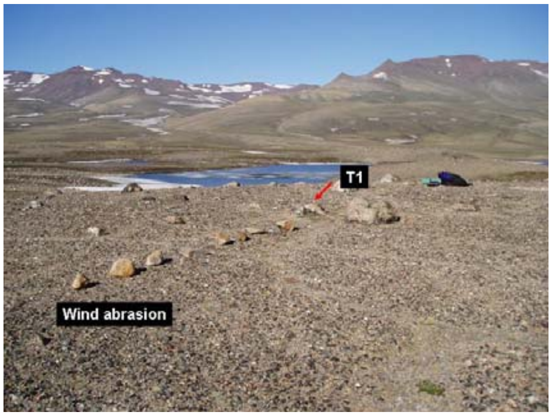
*P4*
A plateau on the Aucella slope c. 20 m northwest of the ZERO-line (peg #??).
Subject: Active layer temperature
UTM: 516936 m E, 8269597 m N
Elevation: c. 820 m a.s.l.
Installation depth: 0, 10, 85 cm
Operation period: 1995-



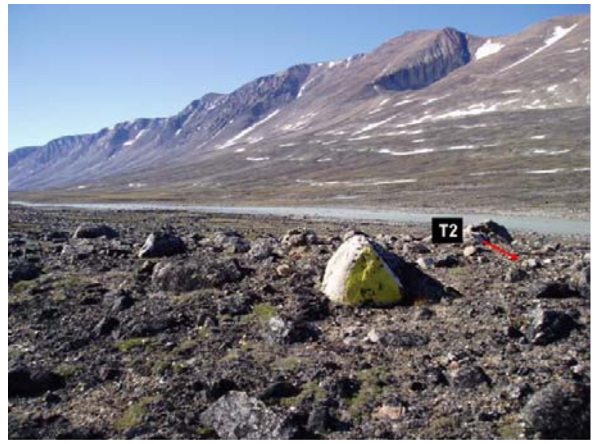

*P5*
On the top of a small rock glacier at the northeast foot of Zackenberg. The front of the rock glacier is about 25 m high.Walk up the talus slope south east of the rock glacier and continue on top of the rock glacier in a northwest direction. About 25 m southwest of the front the site is marked by a pink triangle on a big boulder. Tinytags are found c. 3 m north of this boulder.
Subject: Active layer temperature in very coarse clastic sediment
UTM: 509964 m E, 8267457 m N
Elevation: 259 m a.s.l.
Installation depth: 0, 75, 135 cm
Operation period: 1996-


*P6*
About 400 m southeast of the Zackenberg station in the very wet area c. 50 m south of the southern border in ZEROCALM-2 and c. 125 m southeast of the ZERO-line. The site is marked by an orange cairn in the swampy fen.
Subject: Active layer temperature
UTM: 513068 m E, 8263921 m N
Elevation: 11 m a.s.l.
Installation depth: 0, 10, 30, 60 cm
Operation period: 1997-2002


*P6-new*
Located c.5 m from the old P6 site. TinyTags are placed inside a wateerproof box mounted on steel legs.
Subject: Active layer temperature
UTM: 513068 m E, 8263921 m N
Elevation: 11 m a.s.l.
Installation depth: 0, 10, 30, 50 cm
Operation period: 2000-



*T1*
In the northern part of the moraine hills. About 100 m northeast of Blæsenborg trapping hut. Right east of the lined up yellow painted boulders which are part of a wind polish experiment.
Subject: Air temperature near terrain
UTM: 511090 mE, 8268397 m N
Elevation: 85 m a.s.l.
Installation: c. 10 cm above soil surface
Operation period: 1995-




*T2*
On top of a small hill in the eastern part of Store Sødal c.100 m south of the Zackenberg river. When arriving from east, look for a yellow triangle on a boulder.
Subject: Air temperature near terrain
UTM: 509105 m E, 8269215 m N
Elevation: 129 m a.s.l.
Installation: c. 10 cm above soil surface
Operation period: 1995-


*T3*
On top of Aucella near the end of the ZERO-line.
Subject: Air temperature near terrain
UTM: 518023 m E, 8269902 m N
Elevation: 965 m a.s.l.
Installation: One tinytag c. 10 cm above soil surface
Operation period: 1995-

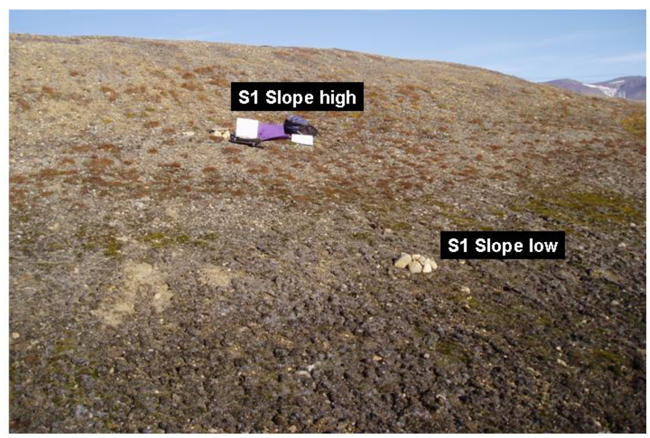
*T4 (will be renamed T5)*
Subject: Air temperature on top of Dome Mountain
UTM: 507408 mE, 8273009 mN
Elevation: 1420 m a.s.l.
Installation: One tinytag in shielded house 2 m above ground.
Operation period: 2004-


*V1*
Near the hydrometric station. Sensor is placed in a tube fixed on the river bed.
Subject: Water temperature at the river bed
UTM: 512538 mE, 8264582 mN
Elevation: 14 m a.s.l.
Installation: Under fluctuating water levels.
Operation period: 1995-1998

*V2*
On the southern side of "Gadekæret" northeast of house number 6.
Subject: Water temperature at the bottom of a pond
UTM: 512916 mE, 8264519 mN
Elevation: 35 m a.s.l.
One TinyTag
Installation: Under fluctuating water levels, but typically under 15 cm of water in July
Operation period: 1995-

*S1*
Traverse through the big snow patch west of the Zackenberg river c. 250 m sothwest of the river crossing wire
Subject: Soil surface temperatures inside and around a large snow patch
UTM: 512209 mE, 8264467 mN
Elevation: ???
Installation: One tinytag on the plateau north of the snow patch ("above"). Two tinytags on the south facing slope within the snow patch ("Slope high" and "Slope low"). One tinytag in front of/ or below the slope in the vegetation c. 10 m south of the stream that drains the snow patch ("Below").
Operation period: 1995-






*N1 (Will be renamed T4)*
On Nansenblokken at the eastern slope of Zackenberg. The TinyTag is located in a stone cairn next to the digital cameras.
Subject: Air temperature on the rock
UTM: 8265315 mN, 510992 mE,
Elevation: 480 m a.s.l.
Operation period: 2002-

*Dry-2*
Adjacent to the BioBasis plot "Dry-2" in the area between the Zackenberg station and the Climate station. The TinyTags are placed inside a waterproof box mounted on steel legs.
Subject: Active layer temperature
UTM: 8265563 mN, 513365 mE
Elevation: 43 m a.s.l.
Installation depth: 0, 15 cm
Operation period: 2002-2004

*Sal-1*
Adjacent to the BioBasis plot "Sal-1". The TinyTags are placed inside a waterproof box mounted on steel legs.
Subject: Active layer temperature
UTM: 8264649 mN, 513045 mE
Elevation: 34 m a.s.l.
Installation depth: 0, 15 cm
Operation period: 2002-

*Sal-2*
Adjacent to the BioBasis plot "Sal-6". The TinyTags are placed inside a waterproof box monted on steel legs.
Subject: Active layer temperature
UTM: 8264692 mN, 513723 mE
Elevation: 40 m a.s.l.
Installation depth: 0, 10, 30 cm
Operation period: 2003-

*Dry-1*
Adjacent to the BioBasis plot "Dry-3" (Fig.1.1.4 in the BioBasis manual). The TinyTags are placed inside a waterproof box monted on steel legs.
Subject: Active layer temperature
UTM: 8265045 mN, 513816 mE
Elevation:
Installation depth: 0, 10, 30 cm
Operation period: 2003-

*Mix-1*
Adjacent to the BioBasis phenology plot Pap-3. The TinyTags are placed inside a waterproof box monted on steel legs.
Subject: Active layer temperature
UTM: 8264348 mN, 513567 mE
Elevation: 35 m a.s.l.
Installation depth: 0, 10, 30 cm
Operation period: 2004-

**Frequency of sampling**
As soon as the datalogger appears from the snow, it must be checked if the logger works. A single green flash at steady intervals indicate that the TinyTag is still logging. Temperature is logged every hour or every second hour year round. Data are off loaded once a year at the end of the season. Batteries are changed every second year.

**Equipment to be used**

TinyTag Plus-dataloggers
Batteries (type)
Screw driver
Laptop with seriel port
Gemini soft ware (GLM)
Software interface cable
Small silica gel backs

**Fig 2.10.** Tinytag dataloggers in a waterproof box in the field.

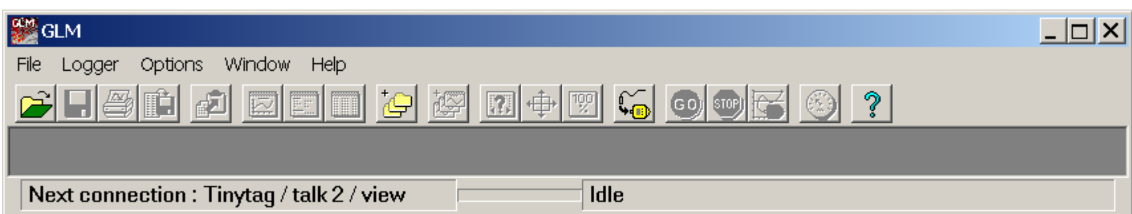
**Procedure for off loading data from the TinyTags**

- Disconnect the datalogger from the sensorcable. Note the exact time of removal. Make sure there is a label on the sensor cable indicating the installation depth and likewise on the logger. Leave cable plugs protected from rain.

- Bring loggers to the station for off loading. Alternatively bring a laptop and off-load the most distant loggers on the spot. Bring extra loggers which have already been started when you go out to empty loggers in the field, as some loggers may need to be changed/repaired.

- Connect the the Tinytag-logger to the parallel port on the computer by using GLM interface cable located with all Tinytag Equipment.

- Choose the Gemmini software program "GLM/Tinytag".




- Press [connect] on the menu. When the TinyTag communicates with the program press [stop].

- To offload data from the logger press [offload]. When all data are retrieved a temperature curve is displayed on the screen. <u>Notice: If the offload button is disabled, the datalogger must be stopped before the readings can be retrieved.</u>

- Save data before you close the window showing the temeprature curve. Choose the GeoBasis\TinyTag dirctory. Name the file after the system: SScmXX, where SS = site and XX= installation depth (ex. P6cm30 is a file from P6 at 30 cm depth (max 8 caracters) and keep the suggested file extension (.ttd).

- Export the file. Press [File] – [Export] - Use the same filename and save it as a text file (.txt).

**Battery change**

- Open the Tinytag by undoing the four screws. Move the small pack of silica gel. Take out the battery. Keep used and new batterries seperately (mark the used battery with a speedmarker).

- Install a new battery. If the battery is accepted, a green light will turn on for a few seconds. If a red light show up it is a warning that the battery is not accepted.

- Check that the black O-ring looks smooth. If not, rub it in silicon or replace it by a new ring from the maintenance-kit. Replace the small silicon back and close the datalogger tight.

**Restart datalogger**

- Connect the logger to the computer. When the TinyTag communicates with the program press [Go]. A new window pops up.

- Follow the instructions and choose the following settings: Title (name of the site and depth), Logging interval (every hour), Reading type (normal), Start options (delayed start), Stop options (stop when full), Alarms (disabled).

- Choose "Delayed start" and specify when you want the logger to start. Make sure that the time on the computer is right and that the time in the software program is right. <u>Notice: Stand by mode of the computer can stop the clock in the tinytag communication program.</u>

- Click the start button to program the settings into the logger. Do not disconnect the logger until you see the message "You may now disconnect the logger".

- Check the Launch confirmation box to see if the logger program is right. Depending on the internal clock the time, the logger start time may change from 14:00 to 13:59 or 14:01. <u>Please, re-program if the time is not exact written hour on the hour.</u>

**Input of data to the local database**

Take a back up of the raw data Files are saved as data from a calendar year (1 January to 31 December). Connect the last part of the previous year to that years file and name the worksheet: SS-XXcm-YYYY (SS=site, XX=installation depth, YYYY=Year, ex. P6-10cm-2002 respond to data from 10 cm depth at P6 in 2002). All files from each site is saved in the folder SSYYYY (SS=site YYYY= year). Make a plot for the calendar year. Control the data quality: Check that the time series are adequate and that temperature interval is reasonable.

**Laboratory work**

Remove defect data and single outliers from the dataset. Interpolate values where single points are missing. Record every manipulation under Remarks. If the data file is complete and looks reasonable, calculate minimum, maximum and mean temperature. Save statistic results in the worksheet "Tinytag statistic" (GeoBasis/Tinytags/Tinytag statistic).

Add information about each Tinytag logger in the file "Tinytag logbook" (GeoBasis/Tinytags/Tinytag logbook).

**Troubleshooting**

# 3 Support of the ClimateBasis monitoring programme

The Climate Station and the Hydrometric station are part of the ClimateBasis program operated by ASIAQ (Greenland Survey). Each year staff from ASIAQ visits Zackenberg for a technical inspection of the ClimateBasis installations. During their visit, GeoBasis staff must be ready to support ClimateBasis staff when necessary.  In the field season GeoBasis staff must carry out inspection of the larger ClimateBasis intallations which includes collection and storing of data from the Climate station and the Hydrometric station.

**Status report**
After arrival in early June a status report must be send to ASIAQ. If there are any breakdowns or operational faillures at the stations, a detailed description must be send to ASIAQ in order to get solutions from them and prepare them for their technical inspection.

## 3.1 The Climate station

The climate station consists of two separate 7.5 m masts "East" (st.640) and "West" (st.641) which have separate sensors and power supply. Instrumentation of the station is given in Table 4 and 5(App3).

**Location**
All masts are located in the *Cassiope* heath right north of the eastern end of the landing strip. It is in the central part of the study area on a meltwater plain representative of large parts of the landscape and the vegetation in the valley.

*East mast (St 640)*
UTM:  8264743 mN, 513382 mE.
Elevation: 45 m a.s.l.
Operation period: 1995-
Instrumentation of the mast: Table 4, App3

*West mast (St 641)*
UTM: 8264738 mN, 513389 mE
Elevation: 45 m a.s.l.
Operation period: 1995-
Instrumentation of the mast: Table 5, App3

*Radiation mast*
Separate radiation mast is placed 10 m south of the main masts.
UTM:
Elevation: 45 m a.s.l.
Operation period: 1997-
Instrumentation of the mast: Table 4, App3

*Pricipitation Gauge*
The Belfort precipitation gauge is located 5 m north of the masts
UTM: 8264751 mN, 513388 mE

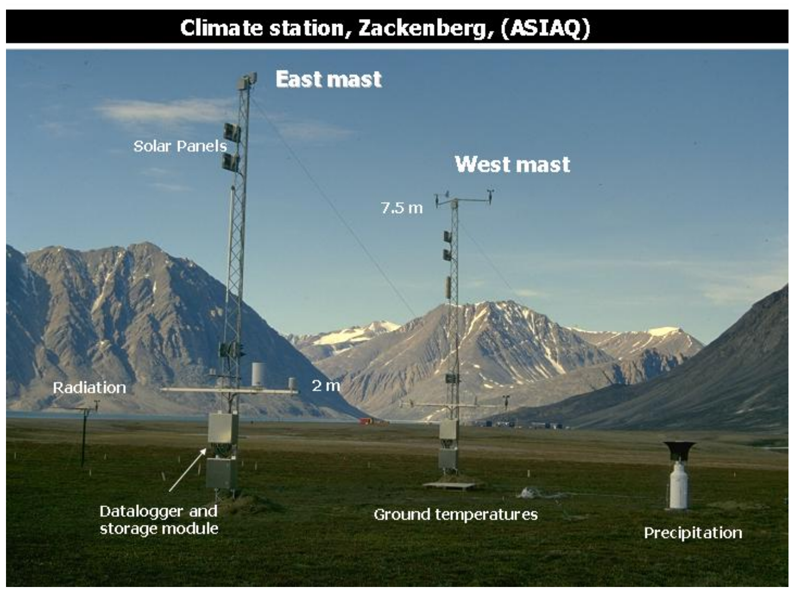



**Fig 3.1** The Climate station includes two almost identical equipped masts East and West, a separate radiation mast, a separate precipitation gauge and a snow mast (outside the photo). The Zackenberg station is seen in the background

Elevation: 45 m a.s.l.
Operation period: 1995-
Instrumentation of the mast: Table 5, App3

**Notice:** Always enter the climate station from the road/track east of the masts, when visiting. Trambling around the masts must be kept to an absolute minimum to protect the vegetation cover from disturbance. Radiation sensors were moved to a separate mast due to damage of the vegetation below the sensors.

**Datastoring and power supply**
Data are stored and collected from two boxes mounted at each of the two main masts. The lower box includes batteries and the upper box includes a datalogger (CR-10X) and a storage modul (SM16M). Batteries are continually charged by solar panels located on top of the masts.

**Frequency**
Data from the climate station are off-loaded imidiately/soon after arrival to the station and once a week during the rest of the season (see work plan, Appendix XX)

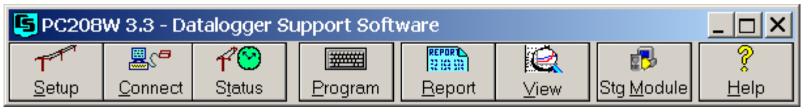
**Procedure for off-loading data from the Climate Station**

- Go to the Climate Station. Open the upper metalbox on the mast and remove the storagemodul SM16M marked “East” or “West”, respectively. Make sure that light is not flashing when removing SM16M, otherwise wait a few seconds (light indicates that data are transferred at that moment).

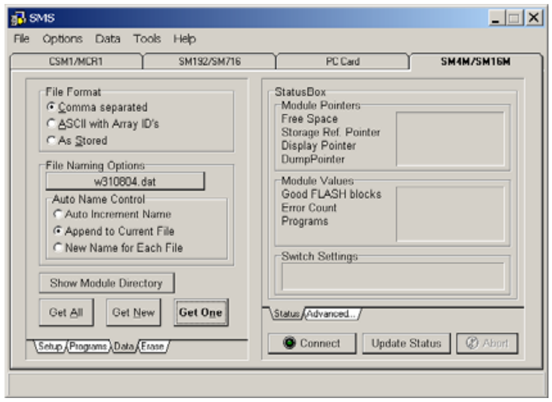
- Record date and time for removal of the storage module. Bring the storage modules back to the Station.

- Connect the storage module to the peripheral port on the SC532 interface (a little gray box connected to the power outlet) by a SC12 cable (blue cable with 9 pin stick in both ends). Connect the SC532 interface to the computer/laptop COM-port by a RS232 cable (gray cable with a 9 pin stick in one end and a 25 pin stick in the other end).

- Turn on the computer and choose the Campbell software program “PC208w”.




- From the main menu choose [Stg module].




- On the next menu choose [SM16M].
- Press [connect] and the computer starts communicating with the storage module.
- Choose [Data] in the lower left side of the screen.
- Write a file name after the principle eYYMMDD, for the eastern mast and wYYMMDD for the western mast (YY is the year, MM is the month and DD is the day) and choose a directory.
- Press [Append to current file] and [Get New]
- After data retrieval press [Disconnect]. Remove the storage module and bring it back to the Climate Station. Replace the storage module marked "West" and "East" in the respective masts.

**Notice**: Data from the masts are stored in the datalogger when the storage modul is decoupled and will be transferred as soon as the storage modul is reconnected.

**Input of data into the local database**
Move the retrieved files to the right GeoBasis directory (GeoBasis\Climate Station\east or west\filename. Open the file and check that the last logged value corresponds to the actual day of year (DOY) and time for removal of the storage module (see Appendix for DOY-calendar). If not -please contact ASIAQ. At the end of the season all data are reported to ASIAQ.

**Contact:**
ASIAQ
Postbox 1003
3900 Nuuk
E-mail: asiaq@asiaq.gl

**Laboratory work**
Relevant charts of parameters from the climate station, such as temperature, wind speed, wind direction, air pressure and precipitation should be presented on the noteboard in the mess room. During the season the charts for the summer should be updated once a week. Summary statistic like monthly mean, maximum and minimum temperatures should also be presented.

| | |
|---|---|

**Fig XX** Equipment used for off loading data

## 3.2 The Hydrometric station

The hydrometric station is another one of the ClimateBasis installations which is maintained by GeoBasis during the season. Further details are given in Chapter 4 under 4.1.1 Automatic water level monitoring.

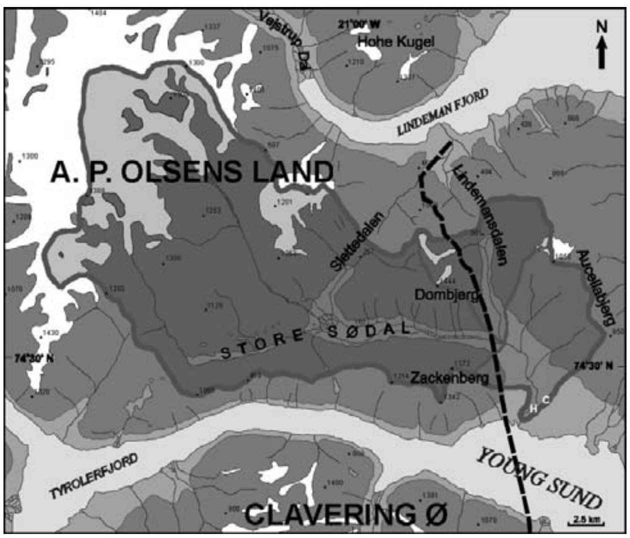
# 4 River water monitoring

The impact of environmental changes are likely to give a response in hydrological conditions and affect the water balance of a given site. Any change in the external climate or in the internal structure of the soil/vegetation system will be reflected in changes in site hydrology. For example changes in evaporation, in soil moisture levels, and in the amount of runoff from the site will lead to a variation in the output of freshwater, sediment and nutrients from land to fiord/ocean.

**Parameters to be measured**
Water level
Water discharge
River water chemistry
Suspended sediment
Suspended organic matter

## 4.1 Water level monitoring

Continuous recordings of water level in Zackenbergelven are used for discharge calculations of the total amount of water draining from the 512 km$^2$ catchment/drainage area outlined in Fig 4.1.



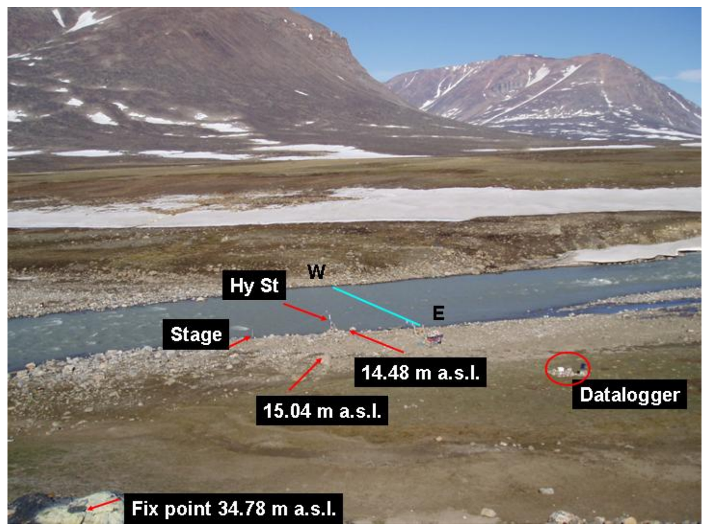




**Fig 4.1**. Map showing the Zackenberg drainage basin (512 km$^2$). The hydrometric station marked by H is located approximately 2 km upstreams from where the Zackenberg river drain out in Young Sund (left). A photo showing the location and sorroundings of the hydrometric station and the river crossing site (right)

### 4.1.1 Automatic water level monitoring

The hydrometric station (st. 642) consists of a sonic range sensor mounted at the end of a 3 m long aluminum cross arm reaching over the river (Fig 4.2). In addition two boxes containing batteries and dataloggers are placed on the shore/bank approximately 30 m northwest of the sensors (Fig 4.3). The station is part of the ClimateBasis programme and operated by ASIAQ. During the season the station is offloaded by GeoBasis staff.

**Location**
*Hydrometric station (st. 642)*
Located at the eastside of Zackenberg river, just south of the river crossing point near the Station (Fig 4.1 and 4.2).
UTM: 8264582 mN 512606 mE,
Elevation: 14 m a.s.l.
Operation: 1995
Instrumentation of the station: Table 6, App3

Batteries and datalogger is located c. 40 m northeast of the hydrometric station (Fig 4.3)
UTM: ???
Elevation: 16 m a.s.l.

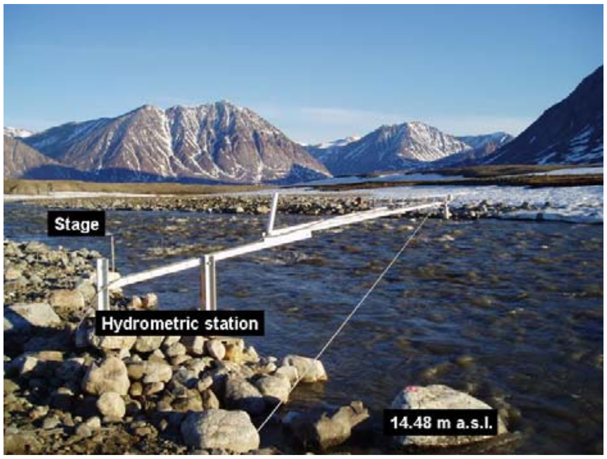


**Fig 4.2** Looking downstream from the hydrometric station. The stage for manual reading of water level is seen in the background.

**Datastoring and powersupply**
Parameters are logged every 15 minutes and data are stored in a datalogger (CR10X) and on a memory card (CSM1). Batteries are continually charged by solar panels.

**Frequency**
Data from the hydrometric station are offloaded imidiately/soon after arrival to the station and once a week during the rest of the season (Field programme, App1)

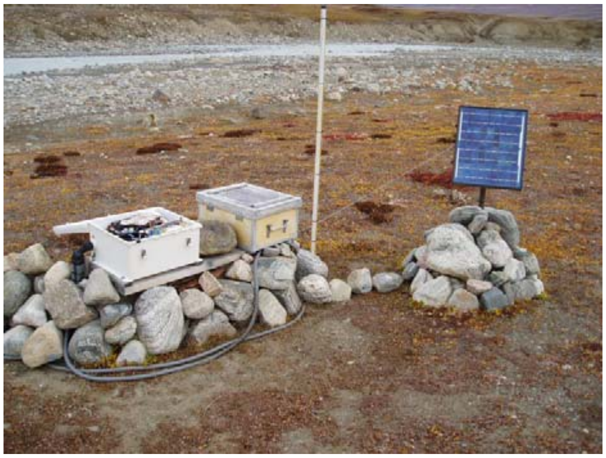


**Fig 4.3** Datastoring and power supply for the hydrometric station.

**Equipment to be used**
Laptop
CSM-1 Card reader
SC532 interface (a little gray box)
SC12 cable (9 pin communication cable, blue)
RS232 cable (gray cable with a 9 pin stick in one end and a 25 pin stick in the other end)
Ranging pole

**Procedure for off loading data from the Hydrometric Station**

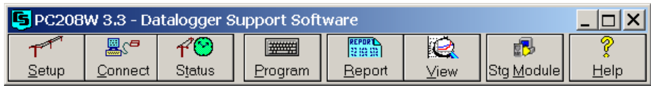
- Go to the hydrometric station. Measure the distance from the SR50sensor (lower point) to the snow/water surface using a ranging pole with cm graduation. Record distance, date and time.

- Open the white plastic box containing the datalogger and batteries and remove the memory card from the card writer. <u>If light is flashing, wait a few seconds before removing the memory card, as light indicate data transfer</u>. Record date and time for removal of memory card. Bring the memory card to the station.

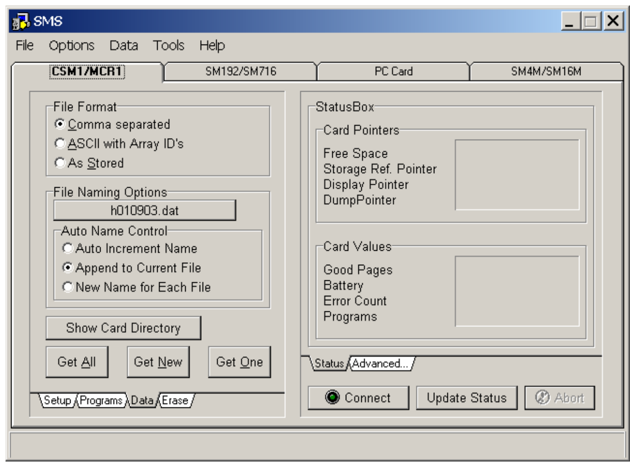
- Insert the memory card in the CSM-1 card reader connected to the peripheral port on the SC532 interface (a little gray box which can be connected to a 9 V battery/transformer or to the power outlet)

- Connect the SC532 interface to the computer/laptop COM-port by a RS232 cable (gray cable with a 9 pin stick in one end and a 25 pin stick in the other end).

- Turn on the computer and choose the Campbell software program “PC208w” on the desk.




- From the main menu choose [Stg module].




- On the menu choose CSM1.

- Press [Connect] and the computer start communicating with the memory card.

- Choose [Data] in the lower left side of the screen.

- Write a file name after the principle hYYMMDD (h=hydro, YY = year, MM = month and DD=day) and choose a directory.

- Press [Append to current file] and [Get New].

- After data retrieval press [Disconnect]. Remove the memory card and bring it back to the hydrometric station and re-insert card in the card writer.

<u>Notice: Data from the station are stored in the datalogger when the memory card is decoupled and will be transferred as soon as the card is reconnected.</u>

**Input of data into the local database**

Move the retrieved data file to the right GeoBasis directory (GeoBasis\Hydrometric station\automatic\filename). Open the file and check that the last logged value corresponds to the actual day of year (DOY) and time for removal of the storage module (DOY-calendar, App5). If not -please contact ASIAQ.

Daily discharge data are reported to GRDC (Irena)

Notice: Use the software programs "Surpher" or "Grapher" when opening the files as these programs are better in handling large time series than Excel.

**Contact:**
ASIAQ
Postbox 1003
3900 Nuuk
E-mail: asiaq@asiaq.gl

**Laboratory work**
Relevant charts of parameters from the hydrometric station, such as water level and water temperature should be presented on the noteboard in the mess room in house 1. During the season charts must be updated once a week.

**Maintenance**

- Wires from the hydrometric station tent to loosen during winter months. Strengthen the wires to keep the station in position. It is important to have/know the exact position of the sonic sensor during the season. Use a level instrument and measure the position at least once per season and before and after any modifications at the hydrometric station that influences the position of the sonic sensor.

- Before the stations are left, make sure that there is enough free space on the storage module. If necessary erase data from the storage module. Choose the [Erase] tag on the main menu. From the erase options choose [Erase Data] This option erases all data but restores any programs on the storage module. The storage module can be left in either "Ring mode" or "Stop mode". Leaving the storage module in "Ring mode" will result in over writing of existing data if the storage module runs out of space and in "Stop mode" the storage module will stop saving data when the storage module is full.

**Troubleshooting**

- If there is no data from the SR 50 sonic sensor there is a spare SR 50 sensor in house number 3 (ASIAQs storage). The sensor can be replaced by clicking of the sensor off at the device/socket near the sensor house.

If the power for any reason has been cut, it might be necessary to re-install the program on the datalogger. This can be done via computer or via storage module. ASIAQ programs are located in the GeoBasis directory: **(GeoBasis\ASIAQ\Zackenberg\Programs**Zack 642 ny CR10X.csi/ .dld

- Procedure for installing programme in the datalogger. Turn on the computer and choose the Campbell software program "PC208w" on the desk. Press [connect] – specify station or datalogger type – [connect] - [asscociate dld.program] – [send]

## 4.1.2 Manual water level monitoring

Water level is manually measured once a day or more depending on the situation. At the beginning of the season a stage is mounted in the river. The stage is stored in the GeoBasis magasin in house number 4. A few meters downstream from the hydrometric station a steel probe is buried in the river bed.

Mount the stage on this probe using plastic strips. Every year the stage must be leveled to get the exact position/elevation. Use the total station (Topcon GTS6) and the fix points on the eastern shore for this purpose. There are three elevation/fix points adjacent to the Hydrometric station (Fix point A, B and C). All situated on the eastern shore.

**Location**
*Stage level*
Located c. 10 m downstreams from the hydrometric station
UTM: 8264586 mN, 512622 mE
Elevation: Must be measured exact every year

*Fix-point A*
Located 2m north of the hydrometric station.
It is marked with a pink circle on top of a big boulder.
UTM: 8264601 mN, 512614 mE
Elevation: 14.48 m a.s.l.

*Fix-point B*
Located 20 m east of the hydrometric station (Fig 4.5).
It is marked by a red cross and 0198 on a big boulder.
UTM: 8264594 mN, 512614 mE
Elevation: 15.04 m a.s.l.

*Fix point C*
Located on top of the plateau/cliff. It is
Marked by a yellow circle and a metal plate
UTM: 8264535 mN, 512683 mE.
Elevation: 34.78 m a.s.l.


**Fig 4.4** Stage level south of the hydrometric station


**Fig 4.5** Fix point B is located on top of the big boulder.

## 4.2 Water discharge measurements
Manually measurements of the water discharge (Q) in the Zackenberg River are needed to establish a Q/h relation/to verify the existing Q/h relation for the river. From the Q/h relation, the discharge can be calculated from the automatic water level data, measured at the hydrometric station. Depending on the river stream velocity the discharge measurement is made from boat or by wading.

**Frequency**
Discharge is measured every day (-or as often as possible) as long as the riverbank is covered in snow. Snow and ice on river bed and banks changes the cross profile and result in a false water level and therefore manual discharge measurements must be performed as often as possible in that period. After the channel is free of snow, discharge is measured about 5 times during the season.

**Location**
Discharge measurements are performed along the wire

at the river crossing (Fig 4.1 and 4.6).

Wire fix point on the western bank :
UTM: 8264588 mN, 512606 mE

Wire fix point on the eastern bank:
UTM: 8264597 mN, 512613 mE

**Equipment to be used**
2 persons are needed
Timer
Folding rule
OTT C31 current meter
Probe with cm division and grip wrench
Digit counter
Waders
Field chart 6, App 2

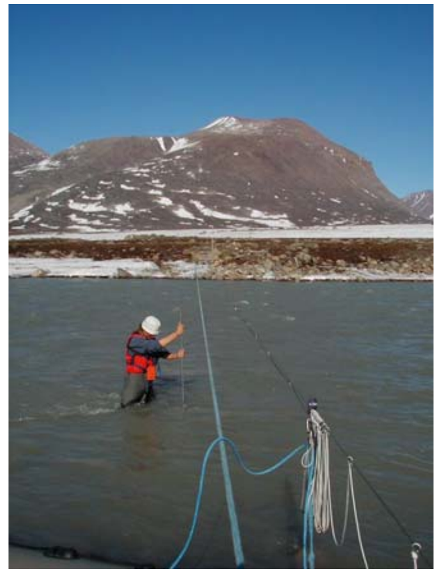


**Fig 4.6** Discharge measurement at the Zackenberg river crossing.

**Procedure for manual discharge measurement**

- Take a digital photo from fix point C, that covers the hydrometric station and the cross profile (Make sure the date and time is written on the photo).
- Take a close up photo of the water stage and the shoreline
- Fill out the field chart before you start (water level, distance from the sonic range sensor (lower point) to the water surface, time, type of current meter, distance from fixed point to the shoreline.
- The cross profile follows the wire at the river crossing. Mark every second meter on the wire with red tape and every 5 meter with blue tape (or check existing marks on the wire)
- The velocity is measured in 15-20 points/profiles/verticals across the river (every second meter). If it is impossible to cross the river in waders the measurement can be done from the boat on the wire. <u>Record on the field chart if the boat is used!!!</u>.
- Measure the depth of water in the first profile. If the depth is < 25 cm the velocity measurement is made in 0.6 x total depth (measured from the surface and down
- If the depth > 25 cm the velocity is measured as a mean between the velocity in 0.2 and 0.8 x total depths (measured from the surface and down).
- Keep the OTT C31 current meter/propeller upstream during measurements.
- For each velocity measurement, the number of complete revolutions of the propeller over a period of 50 seconds is recorded. If less than 100 revolutions in 50 seconds, record for 100 seconds. <u>Remember to record the measurement period on the field chart.</u>

- Record distance to shore from each profile, water depth, and revolutions per 50 seconds
- Measure the distance from the last profile to the shore line. Remarks about ice or snow on the riverbed and banks must be recorded in the field chart.
- Fill out the field chart when you end the measurement (water level, distance from the sonic range sensor (lower point) to the water surface, time).

**Calculation of velocity**
Calculation of the discharge is done by the Midsection-method (Shaw, 1996).

**Latest calibration (26 April 2002) for the current meter OTT C31 is:**

**n = < 0.62 : v = 0.2341* n + 0.016**
**0.62 =< n =< 10.04 : v = 0.2486 * n + 0.007**

*n = number of propeller revolutions in 1/s*
*v = velocity in m/s*

**Fig 4.7** Discharge measurement from the boat

- Calculate the mean velocity (v) in every vertical as v (0.60) or (v (0.20) + v (0.80))/2.
- Multiply mean velocity for every vertical by the depth of the vertical.
- Take half the product (mean velocity * depth) from the first vertical and multiply by the distance between the nearest shore and the first vertical.
- Take the mean of the product from first and second vertical and multiply by the distance between those two verticals.
- Take the mean of the product from second and third vertical and multiply by the distance between those two verticals. Continue like this to the last vertical.
- Take half the product from last vertical and multiply by the distance from the last vertical to the shore.
- Add all results from above to get the actual water discharge.

**Input of data into the local database**
Results are written in the template “Water discharge” (GeoBasis\manual\templates\water\discharge) and stored in (GeoBasis\water discharge\water discharge YYYY\filename) Files are named after the system: wd DDMMYY, where wd=water discharge, DD=day, MM=month, YY=year. At the end of the season, field charts must be sent to ASIAQ including all photos and positions of stage and sensor.

**Maintenance**
Current meter must be returned to the factory for calibration every second year. Latest Calibration were performed in 2002.

**Troubleshooting**
To be filled.

# 4.3 River water chemistry

Water samples are collected on a daily basis in the Zackenberg river and on a frequent basis from the streams contributing/running into the Zackenberg River. The parameters monitored in the water are expected to indicate possible causes and consequences of environmental change in the aquatic environment.

**Parameters to be monitored**

Suspended sediment concentration
Organic content of sediment
Water temperature
pH
Alcalinity
Conductivity

Chloride ($Cl^-$)
Nitrate ($NO_3^-$)
Sulfate ($SO_4^{2-}$)
Calcium ($Ca^{2+}$),
Magnesium ($Mg^{2+}$)
Pottasium ($K^+$)
Sodium ($Na^+$)
Iron ($Fe^{2+}$)
Alluminium ($Al^{3+}$)
Manganese ($Mn^{2+}$)

Dissolved organic carbon (DOC)
Dissolved organic nitrogen (DON)
Ammonia ($NH_4^+$)

**Fig 4.8** Water samples are collected every day at 8 AM. The long metal probr in the foreground is used when taking depth integrating samples.

## 4.3.1 Zackenbergelven

**Location**
The hydrometric station is located at the eastside of the Zackenberg River, just south of the river crossing point down from/near the station (Fig 4.1).
UTM: 8264582 mN 512606 mE
Elevation 14 m a.s.l.

**Frequency**

Water samples are collected every day at 8 am. At special events like heavy rainfall or sudden increases in sediment concentration due to ex. Landslides, sampling must be intensified to every second/fourth hour.

**Equipment to be used for water sampling**
Waders
3 x pre rinsed 1 L sample bottles with cap
Depth integrating sampler (Nelson sampler)
Long probe with bottlecapture/collection device
Conductivity meter (YSI 30) including temperature sensor
Field chart 7, App2

**Procedure for sampling water by depth integrating sampler**

- Rinse the stainless steel collection device in the river water and mount it on the sample bottle. Place the bottle in the bottle capture on the long probe (Fig 4.8).

- Wade into the river and collect the sample reaching up stream from the sampling point. Move the bottle/probe slowly at continuously speed up and down through the water profile until the bottle is almost full (c. 800 ml).

- Repeat the procedure, as two samples of c. 800 ml are needed

- Repeat the procedure with the third bottle and collect c. 250 ml, which will be used for chemical analysis.

**Fig 4.9** Depth integrating sampler and conductivity meter used at the daily sampling.

- Measure conductivity and water temperature, by placing the YSI 30 sensor direct into the river and record results.

- Record general observations as snow and ice drift in the water, snow and ice conditions along the riversides and on the river bottom.

- Record the water level on the stage.

**In the laboratory**

- The two sediment samples (1 L bottles with c. 800 ml) are labelled after the following system DDMMYY-HH- X, where X is 1 or 2 for sample 1 or sample 2. Store sample 1 and 2 in the fridge for later filtration (see section 5.5)

- Measure pH and alkalinity in a sub sample of the collected water for chemical analysis. Follow the procedure provided in section 5.2 and 5.3

- Filtrate 50 ml of the water after the prescription in section 5.4 to prepare for later chemical analysis.

- Label the filtered water sample after the following system: DDMMYY-HH (ex. 230602-08 ~ a sample taken 23 June 2002 at 8 am) and store it cold and dark (prescription in section 5.4).

- At the end of season, bring samples to Institute of Geography. Keep samples cold during transport. Samples are brought to Institute of Geography for further analysis

**Contact:**
Institute of Geography:
Stina Normand Rasmussen
Bo Elberling

Analytical methods used to analyse the water samples at Institute of Geography are described on the homepage www.geogr.ku.dk under Facilities – Laboratory-

**Input of data to the local database**
Write results in the template river water (GeoBasis\manual\templates\river water) and store in (GeoBasis\ river water\river water YYYY)

## 4.3.2 Streams

Water samples from the streams contributing to Zackenbergelven/tributaries are sampled to provide information about the spatial variation due to the very different parrent material the streams drain and to examine a temporal variation during the runoff period (from break up to freeze back)

### Location of sampling sites

| Sampling Site | Easting | Northing | Elev. |
|---|---|---|---|
| Store Sødal | 511750 | 8268706 | |
| Lindeman | 511756 | 8268914 | |
| Palnatoke W | 511848 | 8269019 | |
| Palnatoke E | 512345 | 8268599 | |
| Aucella N | 512400 | 8268002 | |
| Aucella S | 512460 | 8266854 | |
| Rylekær | 513184 | 8265629 | |
| Tørvekær | | | |

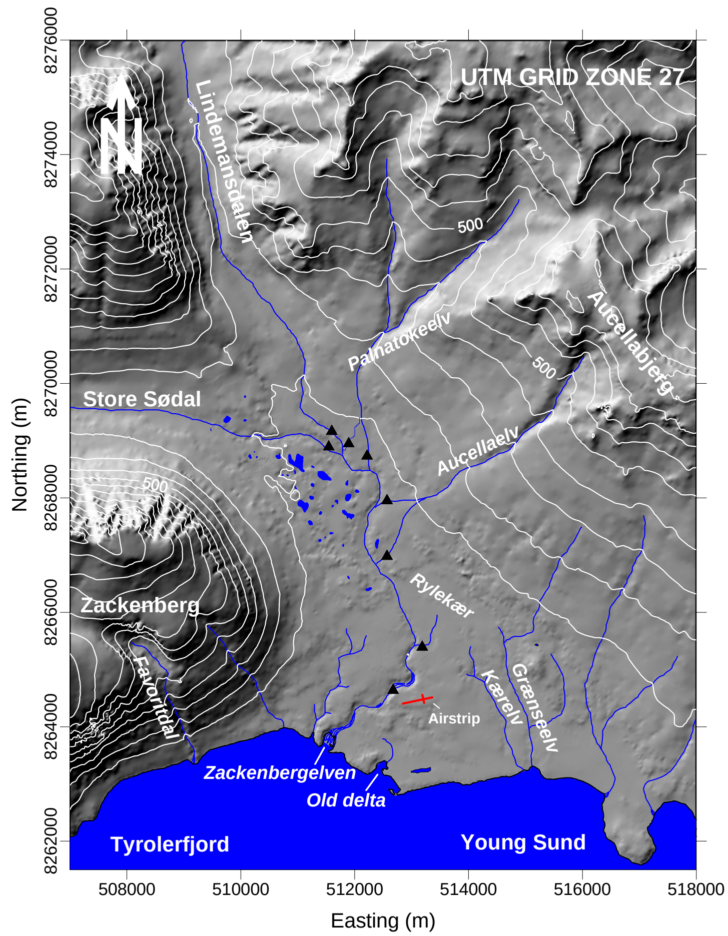



**Fig 4.11** Sampling sites in streams along the Zackenberg river are marked by triangles.

### Frequency of sampling

Water samples from tributaries to Zackenbergelven are collected 5-6 times during the season. First sampling must be carried out as soon as possible after river/stream break up. Rest of the season water is sampled c. every second week. Last sampling must be carried out as late as possible at the end of the season.

### Equipment

Waders
Ranging pole
8 x Pre rinsed 1 L sample bottles with cap
8 x Pre rinsed 250 ml bottles with cap
Conductivity meter (YSI 30)
Field chart 7, App 2
GPS Garmin 12
Digital camera

### Procedure for collecting water samples from streams

- Walk along the Zackenberg river to the sampling sites. Lindemanselven and Palnatoke may be difficult to cross early in the season. Use waders and stick to the ranging pole when crossing.

- Take a digital photo from the site. Place the ranging pole for scale (see photos Fig 4.12 and 4.13)

- Rinse the 250 ml sample bottle with river water, by half filling the bottle. Shake vigorously and discard the rinse water before final filling.

- Fill the bottle, reaching up stream from the sampling point. Leave no airspace in the bottle in order to prevent degassing. Label the bottle after the system xxxDDMMYY:HHMM (xxx=siteID, DD=day, MM=month, YY=year, HH=hour, MM=min)

- Take the 1-liter bottle and sample c. 200-800 ml water for suspended sediment analysis. Sample volume depends on the concentration. Aucella and Palnatoke may be very rich in sediment and therefore a smaller sample is collected for later filtration. Fill the bottle, reaching up stream from the sampling point. Label the bottle after the system from above.

- Measure conductivity and water temperature directly by placing the YSI 30 sensor in the river. Record results.

- Record general observations such as colour, snow and ice drift in the water, snow and ice conditions along the riversides and on the river bottom, size and depth of the stream.

**Fig 4.12** Photo from different sampling sites. Lindemanselven (left). Store Sødal (mid). Palnatoke W (right).

### In the laboratory

- The sample for suspended sediment analysis (1 L bottle) is stored in the fridge for later filtration (see section 5.5). Make sure that the bottle is labelled with date, time and sampling site.

- Measure pH and alkalinity in an unfiltered sub sample from the 250 ml bottle. Follow the procedure provided in section 5.2 and 5.3.

- Filtrate 50 ml of the water according to the procedure in section 5.4.

- Label the filtered water sample after the following system siteDDMMYY (where DD=day, MM=month, YY=year) and store it cold and dark.

- At the end of season, bring samples to Institute of Geography. Keep samples cold during transport. Samples are brought to Institute of Geography for further analysis

**Contact:**
Institute of Geography:
Stina Normand Andersen
Bo Elberling

Analytical methods used to analyse the water samples at Institute of Geography are described on the homepage www.geogr.ku.dk under Facilities – Laboratory-

**Input of data to the database**
Write results in the template river water (GeoBasis\manual\templates\streams) and store in (GeoBasis\streams\streamsYYYY)

**Fig 4.13** Photo from different sites along the river. Water from the eastern and the western part of the basin show a distinct difference in sediment concentration. High suspended sediment concentrations are observed in water from the eastern part (left). Water from Tørvekær/Rylekær (mid). High suspended sediment concentration in the stream Aucella S (right).

**Divers**
This section will be present in the next updated version

# 5 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 presciped temperatures. For longer transportation samples should be stored in a cool/freeze box.

**Fig 5.1** Laboratory in Zackenberg. pH meter next to the magnetic stirrer. The pH electrode is hold by the lower cramp and the acid dispenser is hold by the upper cramp (left). Analytical balance (middle). Device for filtration of water samples. Filtrated water is collected directly into a clean sample bottle. Vacuum is applied by the electrical pump connected to the filtering flask (right).

## 5.1 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 stored in the laboratory.

- Place the conductivity cell in the unfiltered water and read the result expressed in µS/cm. Make sure, that the cell is completely covered in water.

- Record the temperature of the water sample when performing the conductivity measurement. Conductivity of solutions is highly dependent on temperature.

**Notice**: The conductivity meter has different modes:
Conductivity: A measurement of the conductive material in the liquid sample, regardless of temperature
Specific Conductance: Also known as temperature compensated conductivity which automatically adjust the reading to a calculated value which would have been read if the sample had been at 25 °C

## 5.2 pH measurement

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 stored in the laboratory.

- Calibrate the pH-meter before making measurements. A two point calibration in buffer solution pH 4 and pH 7 is performed as close as possible to the sample temperature (follow the guide for the actual pH-meter used). Adjust the temperature on the pH-meter to the temperature of the buffer solutions

- Throughly rinse the electrode in deionized water

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

- Pour 50 ml of unfiltered water into a 100 ml beaker. Use the analytical balance and record the excact weight of the water.

- 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 up to 5-10 minutes).

- Record the pH value and temperature of the water sample when performing the pH measurement field chart.

- Always store the electrode in a storage solution (see operation manual for recommended storage solution) and keep it wet. Never store the electrode in deionized water or leave it dry.

## 5.3 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.

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

- Place the beaker on the magnetic stirrer and add a magnet into the sample solution

- Insert the throughly rinsed and calibrated pH electrode into the sample (make sure that the rotating magnet does not touch the glass electrode. Record the pH in field chart.

- Place the tip of the dispenser in the water and start to add 0.01 M HCl from the special dispenser into the sample. The dispenser contains 2 ml. Notice: To avoid contamination of the HCl, never fill the dispenser direct from the bottle. Pour a small sample into a clean beaker and fill/refill from there

- During the addition of HCl, the water must be gently stirred using the magnetic stirrer. Keep adding HCl until pH in the sample solution drops to pH 4.5.

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

- Record the volume of 0.01 M HCl added

- Alkalinity (mol/L) = (added HCl (ml) * concentration of acid (mol/L))/ volume of sample (ml)

## 5.4 Preparation of samples prior to chemical analysis

**Filtering**
Water samples for further analysis must be filtered before storage. Except from soil water samples which have already been filtered throug the ceramic suction probes (pore size: 2 microns). Filtering of samples should take place within 36 hours of collection

**Equipment to be used**
Filter funnel assembly (Fig 5.1 right)
Milipore Steril filters (milipore 47 mm, 44 µm)
Filtering flask with plastics hose connection and socket (2L)
Vacuum pump
Clean sample bottles with cap (50 ml)

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

- A special string-device (see Fig 5.1 right) allows a clean sample/collection bottle to be placed inside the filtering flask to capture filtered water direct from the funnel. Connect tube from the filtering flask to the pump.

- Add some of the sampled water into the funnel on top of the filtering flask. Start the electrical vacuum pump. After filtration, switch off the pump and open for air intake. Move the funnel from the filtering flask and take out the sample bottle. Use these first captured ml´s of filtered water to rinse the sample bottle and the screw closure/cap. After shaking vigourously, discard the water and place the rinsed sample bottle in the filtering flask again.
- Pour at least 50 ml of your sample into the funnel. Start the pump again. When the rinsed collecting bottle is full of filtered water (there should be no air space left in the bottle) switch off the pump. Carefully, move the full bottle from the filtering flask and close the bottle tight.

- Make sure the bottle has the right label including site ID, date, and installation depth before storage.

- Throw away the used filter before next sample

# 5.5 Suspended sediment

Concentration of suspended sediment in the water samples are determined in the laboratory in Zackenberg.

**Equipment to be used**

Milipore filter assembly (millipore 47 mm) (manifold)
Filters (Whatmann GF/F). Glass fiber filters. Retention diameter of particles 0.7 µm
Filter funnel assembly
Filtering bottle with plastics hose connection and socket (4L)
Filter cups
Vacuum pump
Clean storage bottles/vials with cap
Spray bottle
Filtered water
Tin foil
Slidepockets
Field chart 7, App2


**Fig 5.2** Whatman GF/F filters are used for filtration of suspended sediment samples (left). Milipore filter assembly connected to the vacuum pump. Three samples can be filtered at the same time (Mid). Analytical balance (right).

**Procedure for determination of suspended sediment**

- Leave the water samples in the fridge for at least 1-2 days to allow sediment to settle
- Use the analytical balance to weigh the dry GF/F filters. Use clean fingers to move the filter – not tweezers. Record weight of dry filter in the field chart.
- Place the filter in the manifold funnel assembly and replace the filter cup. A drop of water will help to keep filter in position. Three samples can be run at the same time.
- Dry/wipe the sample bottle + cap (do not shake) on the outside and record the weight in the field chart.
- Pour the water in the filter cup. Start the vacuum pump and open the connection to the filter cup (upright position). Keep pouring water until only the sediment rich water is left in the bottle.

- Shake the bottle and pour the last water in the filter cup. Use filtered water in the spray bottle to flush the sample bottle and make sure that all sediment grains are flushed out of the bottle.

- Weigh the empty bottle + cap and record the weight in the field chart.

- Flush the sides of the filter cup and stop the electrical pump when the sediment on the filter looks dry.

- Move the sediment filter to a small tray of tin foil. Write a sample label/ID next to the filter. Dry the filter in the oven at 105°C until the weight is stable (approximately 24 hours. Remember, that there is normally no power during night in Zackenberg and the drying may take longer than expected if the oven cools down at night).

- Move the filters to the desiccator in order to keep the samples moisture free as they are cooling. Let them cool down to room temperature. Weigh the dry filter with sediment on the analytical balance and record the weight in the field chart.

- Fold the filter half and half again into a quarter. Be careful to keep the sediment in the filter. Wrap the filter in tin foil and place the small package in a labeled slide pocket. Samples from the river is labeled: DDMMYY-HH- 1 or 2 where DD=day, MM=month, YY=year, HH=hour and 1 or 2 refer to sample one or two. Samples from the streams are labeled xxxDDMMYY where xxx is a site ID, DD=day, MM=month, YY=year.

- Bring samples labeled 1 and samples from the streams to Institute of Geography, Copenhagen and samples labeled -2 to Søren Rysgaard DMU, Silkeborg.

**Input of data to local database**
Write results from the field charts in the template river water or streams (GeoBasis\manual\templates\river water or streams) and store data in (GeoBasis\river water\suspended sediment) (GeoBasis\streams\suspended sediment)

## 5.6 Bottle and vial washing

All containers (beakers and bottles) and equipment used in the laboratory must be throughly rinsed before use.

- Wash in a laboratory cleaning agent. Rinse two times in deionized water. Shake to remove drops of water and let it air dry in the rack next to the wash or dry it in the oven

# 6 Soil water monitoring

Soil solution chemistry is likely to be affected by physical and chemical changes in the environment and also to have important effects on the ecosystem processes. In order to monitor terrestrial response to changes in the environmental conditions the fundamental chemical composition of  precipitation and soilwater are measured. By these analyses plant nutrient status and ongoing soil forming processes are reflected. Also physical dynamics are monitored by continous measurements of variables like soil water content and soil temperature.

**Parameters to be measured**
Soil moisture
Soil temperature
Soil water chemistry
Precipitation chemistry

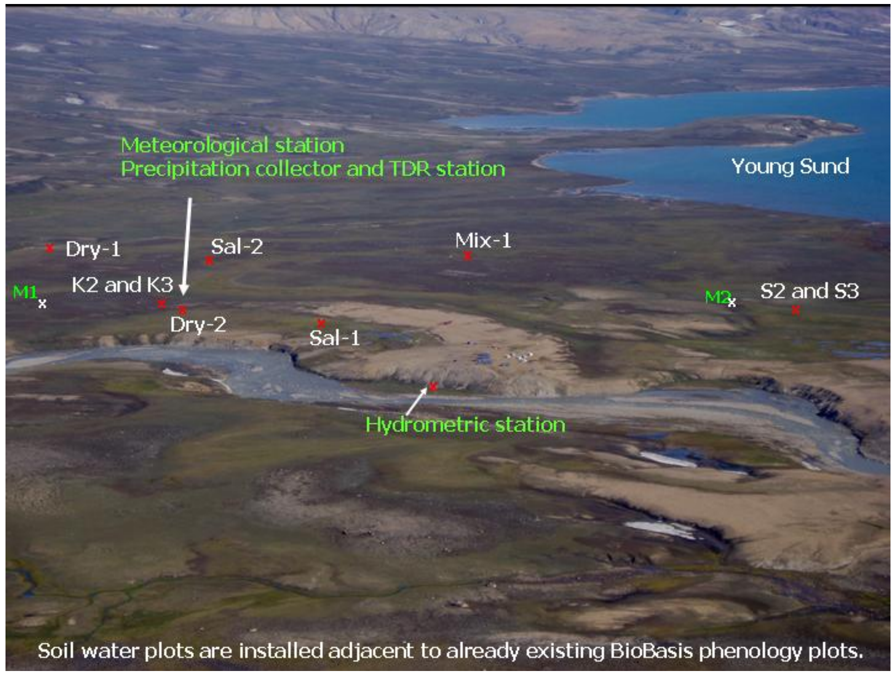



**Fig. 6.1** Photo looking southeast from Nansenblokken. Location of soil water plots are marked by red crosses. Micrometeorological stations are marked by white crosses.  Zackenberg station and the landing strip is in the center of the photo.

## 6.1 Soil moisture

Changes in soil moisture levels are measured in the active layer under the dominating vegetation communities in the valley. Measurements of temperature and soil moisture at different levels in the ground gives important information on hydrological and thermal properties in the active layer. Soil moisture and temperature strongly affect microbial activity in the soil and thereby control the nutrient release into the soil solution. Soil moisture are measured continously/automatic at four sites (M1, M2, M3 and TDR station) and manually at five sites (Dry-1, Dry-2, Sal-1, Sal-2, Mix-1)

### 6.1.1 Automatic soil moisture monitoring

Soil moisture is automatically recorded 10 and 30 cm below the soil surface at the micrometeorological station M2 and M3 and 0-6 cm below the surface at M1 using soil moisture sensors from Delta T (ThetaProbe ML2x). At M1 sensors are installed from the soil surface whereas sensors are installed horizontally upstreams in a pit wall at M2 and M3. Further details about the installation is given in the file „Installation of soilsensors“ (GeoBasis\Climate stations\Installation\). No soil-specific calibration has been performed. At the TDR Station soil moisture are monitored 10, 20, 30, 40, 50, and 60 cm below the soil surface using TDR technique.

**Location**

Location of the sites are shown in Fig 6.1 and 6.2-6.8.

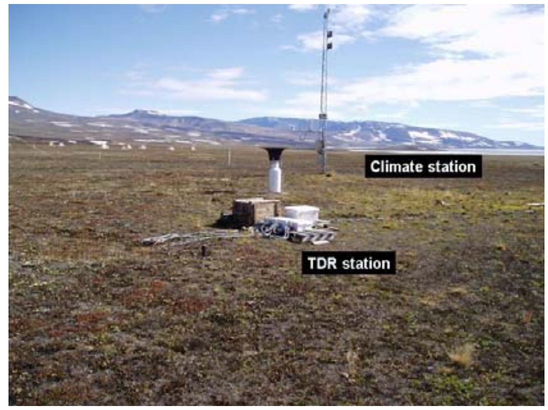



**Fig 6.2** Location of the TDR station near the Climate station

*TDR-station*

Located in a horizontal site dominated by *Cassiope* heath vegetation 15 m north of the Climate station.
UTM:  8264747 mN, 513377 mE
Elevation: 45 m a.s.l.
Installation depth: 10, 20, 30, 40, 50, and 60 cm
Operation period: 1996-
Instrumentation of the station: Table 7, App3

*Micrometeorological station M1*

Located in the almost horizontal *Cassiope* heath a few hundred meters north of the Climate Station.
UTM: 8264893 mN, 513415 m E
Elevation: 45 m a.s.l.
Installation depth: 0-6 cm
Operation period: 2000-
Instrumentation of the station: Table 8, App3

**Fig 6.3** Installation of soil moisture sensor at M1. Legs from the probe are 6 cm long

*Micrometeorological station (M2)*

Located on a south facing slope in the ZEROCALM-2 grid approximately 200 m south of the runway. The mast is situated on the boarder between an upper zone of *Cassiope* and lower zone of *Salix* vegetation
UTM: 8264501 mN, 512748 mE.
Elevation: 17 m a.s.l.
Installation depth: 10 and 30 cm
Operation period: 2003-
Instrumentation of the station:Table 2, App3

*Micrometeorological station (M3)*

Located on a gently south-west facing slope halfway up Aucella. Approximately 100 m north of this station you find point 100 and 101 on the ZERO-line. The dominating vegetation is *Salix.*
UTM-coordinates: 8268250 mN, 516126 mE.
Elevation: 410 m a.s.l.
Installation depth: 10 and 30 cm
Operation period: 2003
Instrumentation of the station: Table 3, App.3

**Frequency**

At stations M2 and M3 soil moisture is registered four times a day year around, whereas the TDR station near the climate station register soil moisture eight times a day year around. Data are off loaded at the beginning and at the end of the season according to the Field programme, App1. During the summer season soil moisture is monitored at station M1 every half hour.

**Procedure for off loading data**

Follow the procedure given in section 2.1.1 for offloading data at M2 and M3. The procedure for off-loading data from the TDR-station skal skrives når stationen kommer op at køre igen. Hvis vi overtager den. Procedure for offloading data from the micrometeorological station M1 are given in section 7.8.

**Input of data to the local database**

Data from M2 and M3 are stored in the directory given in section 2.1.1. Data from M1 are stored in the directory given in section 7.8.

**Maintenance**

Batterier og batterier i storage module
USERs manual from Delta-T Device is located in the GeoBasis library

**Troubleshooting**

## 6.1.2 Manually soil moisture monitoring

Soil moisture is measured manually during the season at five different sites located near the BioBasis phenology plots (Fig 6.1). The sites have almost identical set up. Soil moisture are measured at 5, 10, 30 cm below the soil surface which is the depth where also soil water is collected. Soil temperature is measured at the soil surface and at a depth of 10 and 30 cm. Sensor cables and dataloggers are stored in a waterproof fiberbox mounted on a steel stand/rag. In addition to these in situ readings a handheld/portable soil moisture sensor can be used for spot readings at different places.

**Location**

Location of the sites are shown in Fig 6.1 and 6.4 to 6.8

*Dry-2*

Located in a gently sloping depression downstream from the BioBasis phenology plot "Dry-2" in the area between the Zackenberg station and the Climate station. The site is characterized by snow bed vegetation.
UTM: 8265563 mN, 513365 mE
Elevation: 40 m a.s.l.
Installation depth: 5, 10, 15 cm
Operation period: 2002-2004

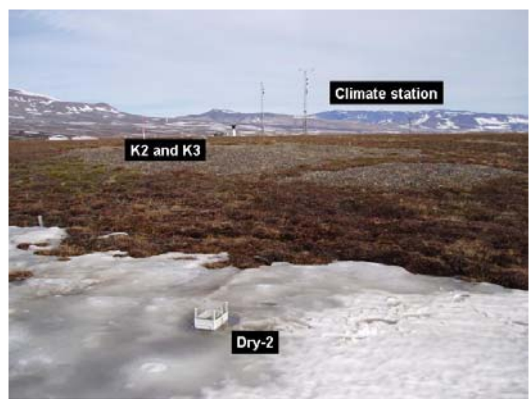



**Fig 6.4** Location of Dry-2. Looking southeast

*Sal-1*

Adjacent to the BioBasis plot "Sal-1". The vegetation is a mixture of *Salix* and grasses.
UTM: 8264649 mN, 513045 mE
Elevation: 34 m a.s.l.
Installation depth: 5, 10, 15 cm
Operation period: 2002-


**Fig 6.5** Location of Sal-1. Looking southwest.

*Sal-2*

Located at a typical snowbed site dominated by salix vegetation. The site is installed c. 15 m downstreams from BioBasis phenology plot “Sal-6”
UTM: 8264692 mN, 513723 mE
Elevation: 40 m a.s.l.
Installation depth: 5, 10, 30 cm
Operation period: 2003-

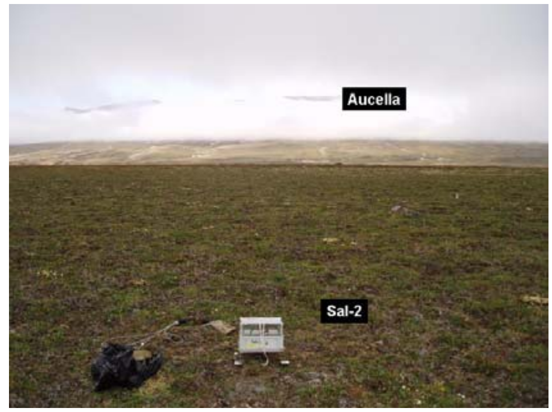


**Fig 6.6** Location of Sal-2. Looking east

*Dry-1*

Dry-1 is located at a typical dry heath site dominated by dryas vegetation. The site is installed approximately 15 m downstreams from the BioBasis-plot Dry-3 which is found near Kærelven west of the climate station.
UTM: 8265045 mN, 513816 mE
Elevation:
Installation depth: 5, 10, 30 cm
Operation period: 2003-

**Fig 6.7** Location of Dry-1. Looking northwest

*Mix-1*

Located c. 15 m downstream from the BioBasis phenology plot Pap-3. The site is charterized by a mixed heath vegetation and a coarse sandy soil.
UTM: 8264348 mN, 513567 mE
Elevation: 35 m a.s.l
Installation depth: 5, 10, 30 cm
Operation period: 2004-

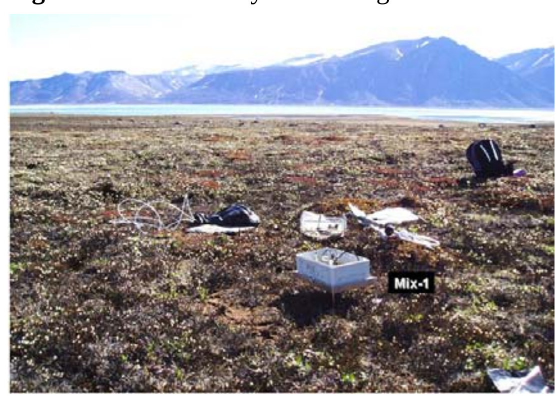


**Fig 6.8** Location of Mix-1. Looking southwest.

**Frequency**

Soil moisture is manually read as soon as the boxes are free of snow. During snowmelt the sensors are read every second day. When soil moisture have reached a steady level readings are performed 1-2 times a week and after rain events. Additional readings are made when soil water is collected from the plots.

**Equipment to be used**

HH2-meter (Delta-T Device)
Field chart 8, App2
Screw driver
Steel prope with graduation

**Fig 6.9** Open waterproof box. The HH2-meter connected to the sensor plug

**Procedure fo reading soil moisture**

- Enter the study plot. Always enter the study plots from a downstream position. Soil sensors are installed upstream from the plot, and the soil above the sensors should not be disturbed by trambling. Site ID is written on the box.

- Where the soil is wet, specially right after snowmelt a wooden boardwalk must be used to protect the vegetation.

- Open the waterproof box by loosening the string and undoing the four screws

- Connect the 25-pin socket from theThetaProbe to the HH2-meter. The HH2-meter initially will assume it is an ML2x probe in mineral soil. For other configurations see the Users Guide.

- Press [Esc] to start the HH2-meter

- Press [Read] and the soil moisture will be displayed in vol%

- Fill out the field chart. Installation depths are written at all sensor cables in the box. Record comments about the plot (snow, standing water, over land flow, vegetation, etc.)

- Measure depth of active layer at three random spots near and downstream from the site.

Indfør spot målinger i ZC-2 row 1 and 6 på de dage, hvor der måles aktivlag

**Input of data to the local database**
Results from the field charts are written into the file (GeoBasis\soil moisture\manual\soil moisture YYYY).

**Maintenance**
Battery A PP3 9 V battery is required for HH2-meter
USERs Guide is found in the GeoBasis library in house number 4.
Hasholts TDR-station Techtronix 1502B
Sikringer

Preparation for vinter: Leave a descicant bag in the waterproof enclosure/box. Tighten the box to the stand using thin steel wire. Ordinary rope are eaten by foxes.

## 6.2 Soil water

Soil water is collected at various depth in soils below caracteristic vegetation communities, using soil water samplers (suction cup lysimeters) from Prenart. The suction sampler used in Zackenberg 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. In the GeoBasis program both temporal and between site variations are monitored.

**Parameters to be monitored**
pH
Conductivity

Chloride ($Cl^-$)
Nitrate ($NO_3^-$)
Sulfate ($SO_4^{2-}$)
Calcium ($Ca^{2+}$)
Magnesium ($Mg^{2+}$)
Pottasium ($K^+$)
Sodium ($Na^+$)
Iron ($Fe^{2+}$)
Alluminium ($Al^{3+}$)
Manganese ($Mn^{2+}$)

Dissolved organic carbon (DOC)
Ammonia ($NH_4^+$)
Phosphate ($PO_4^{3}$)

**Fig 6.10** Suction probe used in Zackenberg

**Fig 6.11** Installed suctionprobe. A Teflon tube connect the probe to the soil surface. Photo not from Zackenberg

**Location**

Soil water has been sampled since 1996 at the two main sites K2 and S2. As an extension of the soil water programme additional sites were installed in 2002 and 2003. These sites are described in the previous section. Position of soil water plots are given in Fig 6.1 and App 4.

*K2*

The main site (K2) is located near the climate station in the relative dry *cassiope* heath.
UTM: 8264760 mN, 513365 mE
Elevation: 45 m a.s.l.
Instalation depth: 5, 10, 15, 20, 30, 40, 50 and 60 cm.
Operation: 1996-

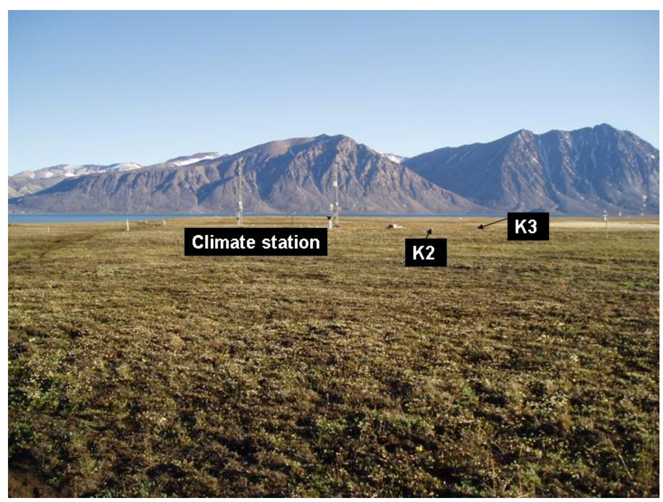



**Fig 6.12** Location of K2 and K3. Looking southwest

*K3*

In 2002 a new installation was made to replace K2. The new installation (K3) is located adjacent to K2 and has suction probes burried in the same depths as K2.
UTM: 8264753 mN, 513349 mE
Elevation: 45 m a.s.l.
Instalation depth: 5, 10, 15, 20, 30, 40, 50 and 60 cm
Operation: 2002-

*S2*

The main site (S2) is located in a *sphagnum-Eriophorum* dominated fen area a few meters south of the ZeroCalm-2 permafrost site. The S site is receiving water from a nearby snowpatch during

most of the summer and is most of the time water logged
UTM: 8263950 mN, 513016 mE
Elevation: 11 m a.s.l.
Instalation depth: 5, 10, 15, 20, 30, 40 and 50 cm
Operation: 1996-

*S3*
In 2002 a new installation was made to replace S2. The new installation (S3) is located next to S2.
UTM: 8263950 mN, 513016 mE
Elevation: 11 m a.s.l.
Instalation depth: 10, 20, 30 and 50 cm
Operation: 2002-

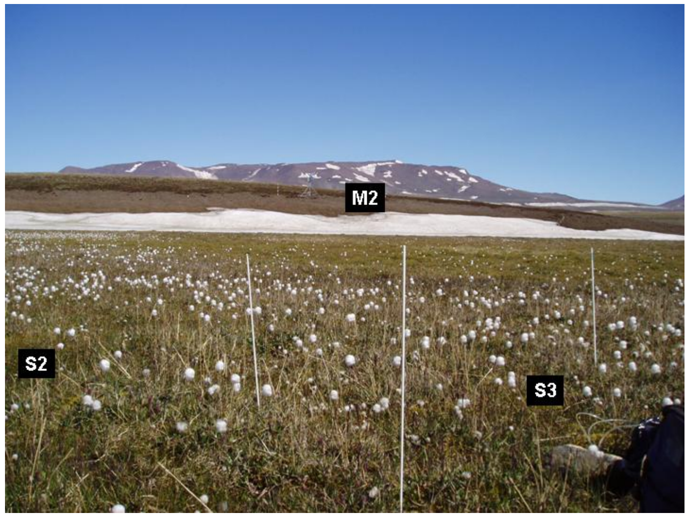


**Fig 6.13** Location of S2 and S3. Looking northeast

**Frequency**
Collection of soil water takes place 4 times during the season:

- Immediately after the active layer thaws and soil water is present (end of June).
- Early in the growing season (July)
- Mid/late growing season (Early August)
- Late season (end of August)

**Equipment to be used for sampling**
Prenart collecting bottles with screw caps (1000 ml)
(-bottles should be rinsed thoroughly and labeled)
Handheld vacuum pump
Field chart 9, App2
Pinch clamps
Silicone rubber tube
Active layer probe
Spare-kit (tubes and fittings)


**Fig 6.14** Hand vacuum pump connected to collecting bottle

**Procedure for sampling soil water**

- At each site, teflon tubes from the burried soil water samplers appear in a bunch on the soil surface. Each tube carries a label which shows the actual installation depth. Where tape is used, a thick ring corresponds to 10 cm and a half size ring to 5 cm.

- Connect the teflon tubes to the pre rinsed collelction bottle. When all connections are tightened the pump is connected to the second outlet on the screw cap by a small piece of rubber tube.

- Open the pinch clip and ensure that the tubing walls have separated. Apply a vacuum of 0.3-0.4 atm (300-400 mbar). Discard the first few ml of water entering the bottle (throw away from the sampling square as that water has been stored in the tubes). Bos artikel 20-30 kPa majBritt 35 kPa

- Apply vacuum and leave bottles for another12-24 hours. Record day and time for application of vacuum on the field chart.

- Depth of the active layer is measured in 5 random points near and downstreams from the site.

- If there is not sufficient soil water (80-100 ml) collected in the bottle after 12-24 hours a new vacuum must be applied. Remember to record day and time for additional application of vacuum.

**Equipment to be used for collection of soil water**
pH-meter
Rubber device to the pH electrode (Fig 6.16) Cover/tube
Buffer solutions (pH 4 and pH 7)
100 ml beaker
De-ionized water in a spray bottle
Cramp
Plastic bottles. Premarked with sample ID

**Fig 6.15** Soil solution collected from Mix-1

**Procedure for collection of soil water**

- Ideally more than 100 ml of soil solution should be collected. Record the volume of water before collecting it (use the calibration on the bottle).

- Record information about the soil solution (is it clear, is there any precipitates etc….)

- Transfer the collected soil solution from the glass bottle to a clean plastic bottle. Make sure that site and depth on the label match the actual site and depth. Bring the water to the station for analysis.

- A pH-value in soil water that has not been exposed to atmospheric concentration of carbon dioxide ($CO_2$), and which therefore reflects the actual soil conditions must be obtained.

- Connect the pump directly to the teflon tube coming from the soil. Use a soft rubber tube and a cramp.

- Apply a strong vacuum (0.8 atm) and wait a few minutes.

- When a few ml of water has entered the tube, close the clamp and decouple the teflon tube.

- Calibrate the pH-meter and mount the small piece of tube around the electrode to make a cup around the pH-sensor.

- Place the  pH electrode in an upside down position hold by the clamp (see fig 6.16 right)

- Transfer the soil water from the tube to the small cup around the electrode.

- Read the pH value imidiately, as the pH-value will keep increasing when the soil water is exposed to the atmosphere.

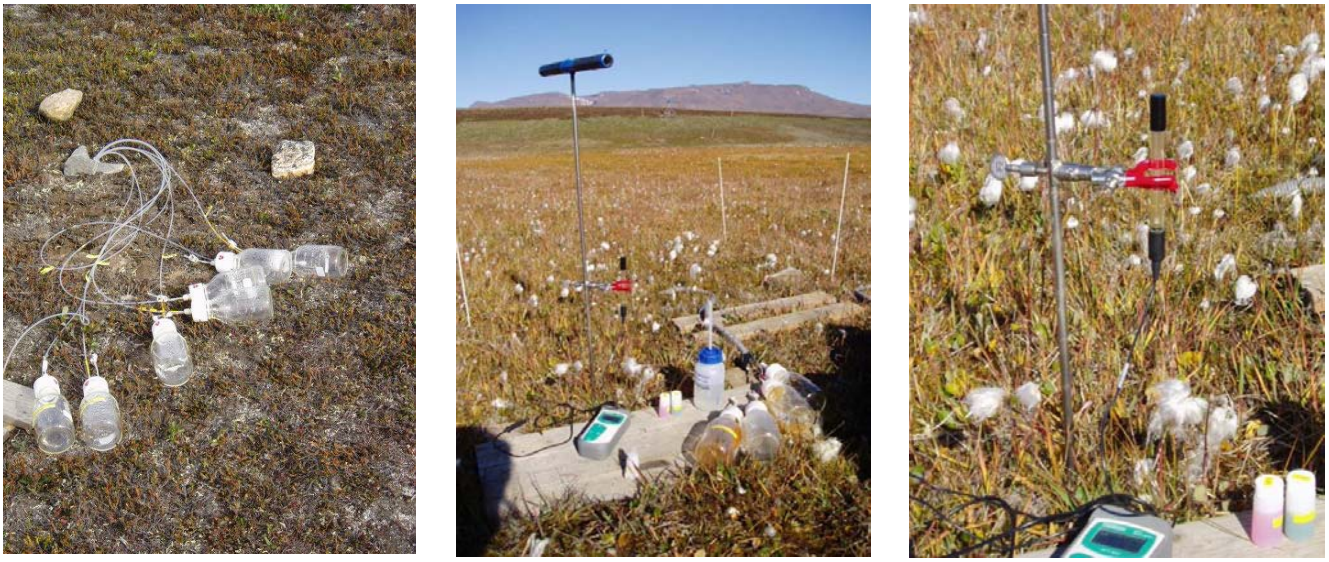


**Fig 6.16** Collecting bottles at the K3 site (left). Field pH analyses at S3 (middle). A cramp is mounted on the probe and used to hold the electrode. To measure pH in a limited amount of water an open plastic cap is placed around the elctrode to establish a small cup. The electrode is kept in an upside down position and soil solution is transferred to the cup (right)

## Laboratory work

- Conductivity is measured in the unfiltered soil water sample according to the procedure given in section 5.1.

- Fill a pre-rinsed 50 ml vial with a sub sample of soil water for further analysis. Preferably the vial/plastic bottle should be filled to leave no air space.

- Fill a pre-rinsed 15 ml vial with a sub sample of soil water for further analysis (leave space for extension due to freezing of the subsample)

- Label the vials after the system: ID-DDMMYY-XX, where, ID=site, DD=Day, MM=Month, YY=Year, XX= installation depth.

- Store the 50 ml sample cold <5°C and dark dark in accordance with guidelines in section 5.4

- Store the 15 ml sample in the freezer <18°C

- The rest of the sample is used for pH and alcalinity analysis. Preferrably 50 ml are needed but in case of limited amounts, samples down to 15 ml can be used. pH and alcalinity tests are made on the same sample according to the procedures given in section 5.2 and 5.3

- After the season all soil water samples are brought to Denmark. Keep frozen samples frozen during transport and cold samples cold during transport. All 50 ml subsamples are brougt to Institute of Geography for further analysis and all 15 ml subsamples are brought to Botanical Institute for further analysis.

**Contact:**
Institute of Geography:
Stina Normand Rasmussen
Bo Elberling

Botanical Institute
Anders Michelsen

Analytical methods used to analyse the water samples at Institute of Geography are described on the homepage www.geogr.ku.dk under [Facilities] – [Laboratory]-

**Input of data to the database**
Results from the field charts are written in the file (Geobasis\manual\templates\soil water) and stored in the directory (Geobasis\Soil water\Soilwater YYYY).

**Maintenance**
*Specification and detection limits:*

- Prenart super quartz soil water samplers consist of a 95 mm long cylindrical ceramic probe (21 mm in diameter). In one end, a 5 mm teflon tube links the probe to a 500 ml glass collecting bottle. Specification and detection limits from the laboratory are given in App 7

*Replacement of suction probes:*

- The life of a suction probe is limited and replacements must be done once in a while. Clogging and bad hydraulic contact may cause imidiate replacement while othere suction probes can work for years without any problems. Time for installation of the soil water samplers is given in Table 9)

´

- Follow the procedure for installation given by Prenart equipment ApS

*Preparation for vinter storage*:

- Hide all above soil surface tubes in a hard tube (panserslange) to prevent foxes and other animals to chew the lines. Bring all glass bottles inside.

**Troubleshooting/Tips**
*The collection bottle loose applied vacuum:*

- Check if teflon tube has damages or chewing marks
- Check that all connections are tightened and fittings are OK. It sometimes help to change fittings, bottle, or cap for a better fit

## 6.3 Precipitation

Rainwater is collected in a continously open gauge in order to be able to measure the chemical composition of the bulk precipitation. The gauge consists of an open plastic funnel mounted on a plastic bottle. Between the funnel and the collector is a filter, of 1mm mesh teflon. The collector is mounted on a steel probe/stand wired to the ground (Fig 6.17). Upper surface of the collector is 2 m above ground and the open area is 104 $cm^2$.

**Location**
The open rain gauge is located adjacent to the Climate Station in the *Cassiope* heath right north of the eastern end of the landing strip (Fig.1.1).
UTM-coordinates: 8264751 mN, 513388 mE.
Elevation: 45 m a.s.l.
Operation: 2002-

**Frequency**
Water is collected soon after arrival and after every rain event during the season.

**Equipment**
A plastic gauge rinsed in de-ionized water (there are spare ones in the GeoBasis magasin in house number 4),
Field chart 7, App2

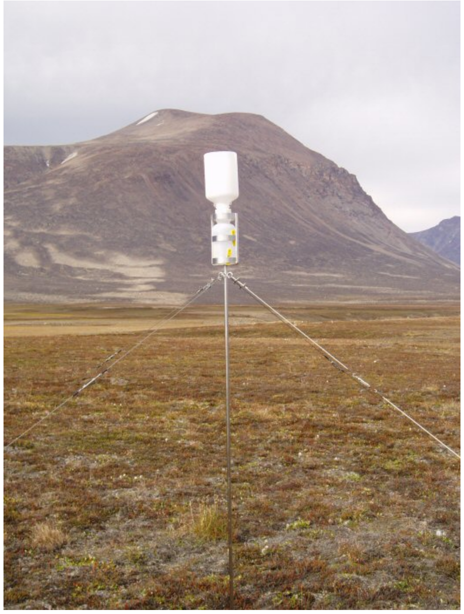


**Fig 6.17** Open precipitation gauge near the Climate station

**Procedure for collection of rain water**

- Remove the plastic bottle and funnel from the stand and replace with an empty clean one. Secure the bottle in the stand by pressing the yellow wedges in between the stand and the bottle and check that the top of the funnel is horizontal.
- Record date and time for collection and approximately period/duration off the rain event.
- Record any obvious signs of bird droppings, dust, smuts, or any other disturbances.
- Bring the rain gauge to the laboratory
- Determine the volume of water by weight
- Measure conductivity in the unfiltered water sample according to the method provided in section 5.1
- Measure pH in a subsample of the unfiltered sample according to the method provided in section 5.2
- Filter the part of the sample that have not been in contact with the pH-electrode according to the method provided in section 5.4
- Label the sample after the princip R-ddmmyy (R=rain, dd=day, mm=month, yy=year)
- Store the sample cold <5°C and dark (Eller måske frossen, da den ikke kan fyldes helt op og derved ikke blive luftfri)
- Bring samples to Institute of Geography, where they will be analysed in the laboratory.

**Contact:** Stina eller Bo Elberling

Notice: In order to calculate deposition fluxes use the volume of water measured at the Climate station, as the bulk collector may give less accurate estimates on the volume.

**Input of data to the local database**

Write results in the template soil water (GeoBasis\manual\templates\Precipitation) and store in (GeoBasis\ precipitation\Precipitation YYYY)

# 7 Carbon dioxide-flux monitoring

Carbon dioxide exchange rates are measured at a heath site in Zackenberg to estimate to what extend the *Cassiope* heath act like a sinc or a source of $CO_2$. The micrometeorological station is operated only in the summer season or as long as GeoBasis staff is at the station. It is important to start up the station as soon as possible after arrival and to close it down as late as possible before leaving the station, as the ends of the season are of special interest.

### Parameters to be monitored

Vertical fluxes of $CO_2$ and water vapour
Windspeed
Wind direction
Soil temperature in 3 and 10 cm depth and at the soil surface
Air temperature,
Soil moisture in the soil surface (0-6 cm)
Relative humidity
Infra red temperature at the surface/canopy
Heat flux

Soil moisture

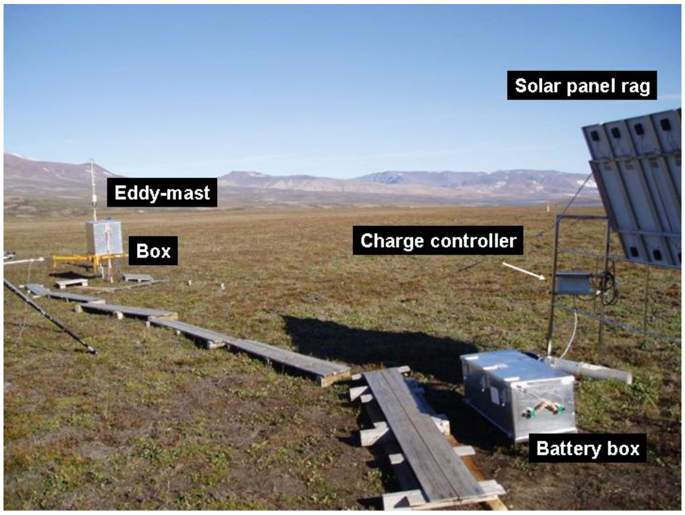


**Fig 7.1** The set-up at the micrometerological station (M1)

### The micrometeorological station

The micrometeorological site (M1) is a set up including an eddy correlation mast, a rag with 7 solar panels mounted on a stainless steel stand, an alumium box containing 5 acumulators, a box/cupboard which can be opened from two sides and a lot of board walks.

### Location

The micrometeorological station (M1) is located in a well drained *Cassiope* heath site about 150 m north of the climate station. The site is marked by stainless steel stand/rag left during the winter. The spot for position of the mast is marked by a ranging pole.
UTM: 8264887 mN, 513420 mE (Eddy mast)
UTM: 8264887 mN, 513403 mE (Solar panels)
Elevation: 45 m a.s.l.
Operation period: 2000-
Instrumentation of M1: Table 8, App3

**Fig 7.2** Location of the micrometeorological station (M1)

**Notice:** The area south east of the mast is considered the footprint area of the mast and all activity in this area should be limited in order to protect the vegetation and not to influence the $CO_2$ level

## 7.1 Installation of the micrometeorological station

Soon after arrival the micrometeorological station should be installed. All equipment can be transported to the site by the station vehicle (ARGO) as long as snow is covering the ground. Most equipment is stored in house number 3.

**Eddy mast:**

- Place the center of the mast on the snow where the pole is located. Avoid too much walking around the mast. Keep influence on the snow pack to an absolute minimum. At least the area east of the mast should be totally free of foot steps as this is the area where surface temperature will be measured.

- Place the aluminum box/enclosure (which can be opened from both sides) on the stainless steel stand and secure it with a string.

- Mount the solar panel rag on the steel stand. At least three people are needed for this project as the rag is large and heavy

- Install the various sensors on the mast according to the positions/elevations given in Table 8, App3 and as can be seen from the installation photos. Fill out the installation chart (GeoBasis\Micrometeorological station\installation)

- Center of the anemometer is placed 3 m above surface. There is a mark indicating north at the anemometer. This mark is pointed towards magnetic north. A precise orientation is very important.

- Place the air intake (sampling tube) 3 m above surface on the western side of the anemometer. This position will influence less on the anemometer as wind direction is mainly from southeast

- Install temperature sensor 2 m above surface

- Install IR sensor on the cross arm 1 m above surface pointing on the vegetation between the legs of the mast. The sensor should point down eastwards

- Use strips to secure lines, cables and tubes along the mast. Bring the cables into the cupboard through the hole in the bottom.

- Place boardwalks around the cupboard and in a line from the batteries to the mast to reduce impact on the vegetation. Leave two Zarges boxes containing all kind of spare parts and chemicals for the maintenance of the mast out there. They are used as workspace when chemicals are changed in the tubes

Seven solar panels charge the five 12 V batteries which supplies the micrometeorological station with power. A charger/relay/lade regulator is connected between the solar panels and the batteries. Batteries are left in the box during vinter.

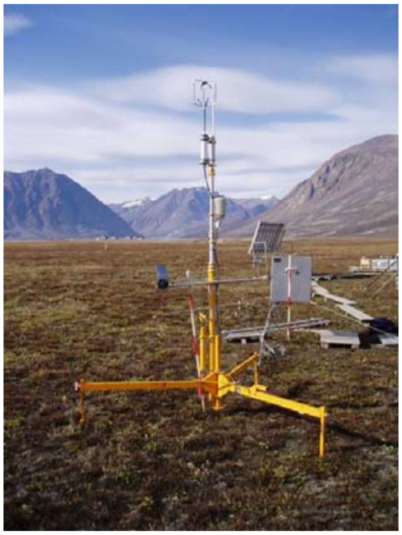


**Fig 7.3** Eddy correlation mast (left). The 5 batteries powered by the solar panel rag (middle). Air intake and 3-D anamometer mounted on top of the mast (3 m above surface) (right).

- Disconnect the cables to check capacity of each battery before power cable from the solar panel rag is connected. If a single battery is lower than the rest, replace it with a spare battery. Be careful not to touch the side of the box with any of the cable ends as that will cause a short circuit.

- To prevent gasses to concentrate inside the box, keep the battery box aerated and not tightly closed.

- Connect a power cable from the batteries to the instruments in the cupboard

**Prepation before start up**

- Change internal chemicals at least 24 hours before start up.

- Insert new filters and chemicals in the chemical tubes on the Li-6262 analyzer

  - Connect Li-6262 analyzer, diaphragm pump and computer after the wiring diagram given in the User Guide section XX. Labels on the cables will help to connect the right parts

  - Calibrate the analyzer as the first thing (see section 7.5)

**Program**: Data collecting and processing is based on Edisol software (Moncrieff et al, 1997)

**Edisol (start)**

*To start the Eddycorrelation data program, Edisol:*

- Start the computer.
- Press the “MS-DOS”on the desk top

*Open calibration file:*

- Press [F10]
- Choose [Calibration]

*Load file:*

- Choose [ZD_2000.cal] (press tabulator and use the arrovs to move around) [Enter]

*Start datalogging:*

- Choose [Log] on the menu and choose [solent]-[Enter]

*Set up solent:*

Seriel port (com1) Baud rate 19200 (eller 9600)
Number of analogue inputs: 2
Solent data mode: Calibrated u v w
Orientation: 0
If the above list is OK: [enter]

Skærmbillede

*Logging parameters:*

Moving average: 200
Flux average period: 30
File name prefix: d
Number of axes: 3
Atm. Pressure : 1005
If the above list is OK: [enter]

*Raw Data:*

Save: yes
File name prefix: d
File length (min): 30

If the above list is OK: [enter]

Skærmbillede

*Define instrument channels:*

| | |
|---|---|
| Anemometer u | 1 |
| Temperature | 4 |
| Carbon dioxide | 5 |
| Water vapour | 6 |

If the above list is OK: [enter]

Now the program tries to establish contact with the Solent. **Notice:** If the message [cannot make contact with Solent] appears, then switch off the Sonic and turn it on again quicly.

**Edisol (turn off)**

To turn off the Eddycorrelation data program:

- Stop datalogging: [ctrl] [Q]
- Exit Edisol: [Alt] [X] and windows start up automatically

## 7.2 Procedure for every day check of the micrometeorological station M1

A daily check is carried out in order to prevent data loss in case of break down in the system

- Fill out the daily observation scheme for M1 8field chart 10, App2. DOY, Time, Observer…..

- Record voltage on the batteries in the box. If battery charge is running lower than 12 V, it may be necessary to use a portable generator to charge the batteries -or to shut down the station. In case the station must be shut down, leave the 21X datalogger running (it has a very small power consumption). Computer, Li-6262 and pumps must be turned off until the batteries are recharged. For use of generator see section 7.7

**Fig 7.4** The box that houses the Licor-6262, computer, and datalogger. The box opened from the front (left). The box opened from the back (right).

- Read display on the LI-6262. Press [1] to read the $CO_2$-concentration (µmol/mol) and the $H_2O$-concentration (mmol/mol). Press [2] to read Licor pressure (hPa) and temperature (˚C).

- Press the space bar to activate the computer screen and record values from the Edisol program in the scheme.

- On the 21X datalogger time are displayed by pressing [*] [5]. To see data in the different channels press [*] [6]. Move forward thorugh the channels by pressing [A] and backwards by pressing [B]. Battery voltage is shown in channel 18. (Prompt scheem for the datalogger is in the folder).

- Report observations about the weather: wind, wind direction, precipitation, cloud cover, type of clouds, snow cover, snow condition…..

- Report observations about the ground surface and vegetation. Drainage, vegetation condition, flowering….

- Finally, report any operations carried out on the system

## 7.3 Procedure for changing chemicals

Read the description of the chemicals and the safety precautions: Natronkalk and Magnesiumperchlorat. Handsker, beskyttelsesbriller og åndedrætsmake anbefales)

**Frequency**
The chemical tubes on the Li-6262 are changed every second week or if there is any sign of leakiness in the system.

**Equipment to be used**
Spare tubes
Slip joint plier (Papegøje
Funnel
*Cotton wool???*
Tweezer,
Hand drill/auger
Safety spectacles
Natronkalk
Magnesiumperchlorat
Gellman adhesive discs
Silicon
Knife

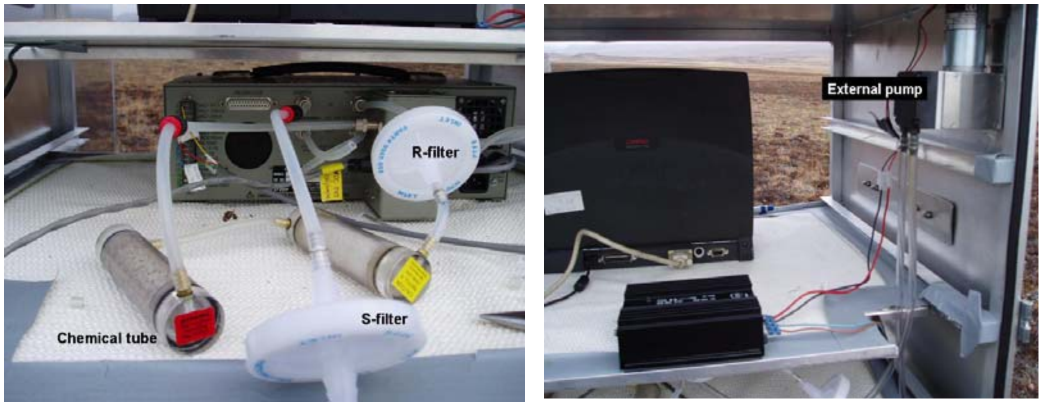


**Fig 7.5** Licor-6262 from the back. Chemical tubes and filters are changed on a regular basis (left). The external pump is mounted on the side of the box and connected to a regulator 8right).

**Prepare a new set of tubes**
- Find the spare set of chemical tubes in the alumium box. Check adhesive filters and O-rings in both ends of the tube before filling. If necessary change the adhesive filter and rub the O-ring in silicon (Fig 7.6).
- Place a small piece of *cotton wool* in one end of the tube. Pour chemicals into the tube. Each tube is labelled either Magnesium Perchlorat or Natron kalk.
- Tap the tube to compact the chemicals and place a small piece of cotton wool on top before the tube is well tigthened. Brug en papegøjetang (Slip joint plier).

**Changing the tubes**
- Turn off the Edisol program according to the procedure given in section 7.1
- Turn off the external pump on the contact/switch.
- Turn off the reference pump placed on the backside of the Li-6262.
- Remove the set of chemical tubes from the sockets and replace with the new set.
- To prevent any leakiness make sure the the tube ends are clean-cut before connecting them in the sockets. Rub the ends on the outside in a bit of silicon before inserting them in the sockets.


**Fig 7.6** Change of chemicals in the field (right). Chemical tubes (left).

## 7.4 Procedure for changing filters

**Frequency**
The Sample filter (S) infront of the “sample in” cell is changed once a week and the Reference filter (R) infront of the”reference”cell is changed every month. Filters on the Li-6262 are changed when the system is switched off anyway (during chemical change or calibration).

**Equipment to be used**
Gellman filters (9967-008)
Knife

**Changing filters**

- Turn off the Edisol program according to the procedure given in section 7.1
- Turn off the external pump on the contact/switch.
- Turn off the reference pump placed on the backside of the Li-6262.
- Remove the filter by cutting the tubes near the metalbranch on the filter.
- Connect a new filter to the tubes. It may be necessary to widen out the end of the tube to be able to squeze it all the way around the filterbranch.
- Make sure the filter is turned right so that the inlet/outlet is in the right direction according to the direction of the air stream (see diagram XX).
- Start the system again. Start the reference pump. Start the external pump. Start up the Edisol program according to section 7.1

## 7.5 Procedure for calibration of the Li-6262 analyzer

Zero and span-calibration are carried out when the system is switched off anyway (during chemical change). Perform the Zero calibration first.

**Frequency**
Calibration of the Li-6262 is done when the system is installed and appoximately every third week during the season (or when it is concidered necessary).

**Equipment to be used**
Span $CO_2$ gas (of known concentration)
Manometer/presure device

- Turn off the Edisol program according to the procedure given in section 7.1
- Turn off the external pump on the contact/switch.
- Turn off the reference pump placed on the backside of the Li-6262.

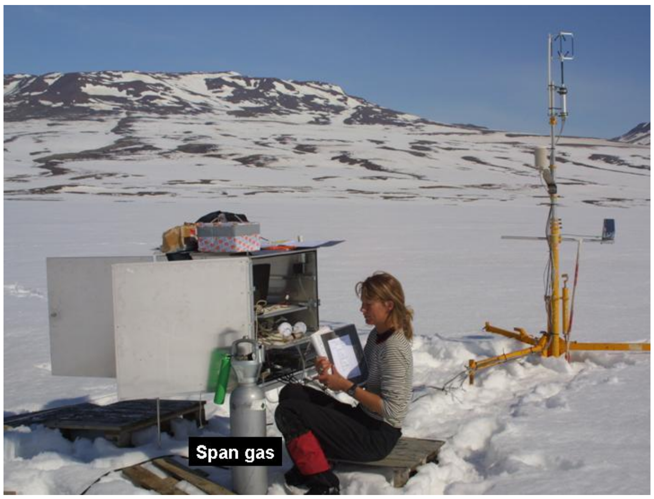



**Fig 7.7** Calibration of the Licor-6262 (left). Span gas connected to the sample cell on the Licor (right).

### 7.5.1 Zero calibration

- Connect the tubes after the diagram (fig XX).
- Turn on the reference pump on the Li-6262. Wait untill values on the Li-6262 display are stable. Record the values in the calibration scheme.
- Adjust the $CO_2$ and $H_2O$ values to 0.0 on the ZERO-buttons. In case it is not possible to adjust the $H_2O$ value to 0.0 write down the off set in the calibration scheme (Field chart 10, App2).

### 7.5.2 Span calibration

- Connect the tubes after the diagram (fig.XX).
- Place the gascylinder in an upright position near the Li-6262. Mount the manometer and connect the gas tube to the sample cell
- Switch on the Li-6262 reference pump to empty the system.

- Turn on the gas and flush the system. First shortly at 7 L/s and then at 2 L/s. Wait for the value on the display to stabelize. Record the value in the calibration scheme (Field chart 10, App2). Adjust on the SPAN-buttons to the right concentration of the gas.

- Switch off the pump and decouple the span gas.

- Arrange the tubes for normal set up (fig. XX)

**Restarting the system**

- Start the reference pump. Start the external pump. Start up the Edisol program according to section 7.1.

- Check that the values are OK. Values in the lower line on the screen are half hourly average values and will not be initialized before the next halfhour file is produced.

**Notice:** If the values from the edisol program are strange after the calibration then check that cables in "signal out" on the backside of the LI-6262 are not loose. Otherwise leave it running. It might change to a prober level (which means a level sligthly above what is shown on the Li-6262 display. If not. - Please contact Thomas Friborg.

## 7.6 Procedure for offloading data

Data from the Eddycorrelation mast and Li-6262 are stored on the computer hard disc in the folder. (C:\Edisol\......) Files are named after the following system D-DOY-HHMM.slt, where D=Dry, DOY=Day of Year, HH = hour, MM=minute. (Ex. D1641230.slt is a file from the dry heath site saved on day 164 at 12:30). The size of a proper 30 minutes flux file is c. 440 KB.

Data from the 21X datalogger are stored on a storage module (SM4M).

**Frequency**

Data are offloasded once a week. Preferrably, when the system is shut down anyway.

**Offlaoding Edisol data**

- Turn off the Edisol program according to the procedure given in section 7.1

- Exit DOS and return to Windows.

- Insert the empty 260 MB PCMCIA-card in the computer.

- Copy files from the harddisc to the memory card.

- Record exact time and date for off loading.

- Always check that there is enough free space on the harddisc to store files from the Edisol program. Free space is written on the Edisol screen. Every half hour 440 KB is stored.

- Bring the card to the station. Transfer data from the memory card to the GeoBasis computer harddisc. Save all files under (GeoBasis\Micrometeorological station\Edisol\foldername) in a folder called "Ed DDMMYY", where Ed= Edisol, DD=day MM=month YY=year.

- Only when all data files are saved in more than one copy, data on the M1 computer harddisc can be deleted.

**Offlaoding data from the 21X datalogger**

- Record exact time for removal of the storage module (SM4M) from the 21 X datalogger
- Bring the storage module (SM4M) from the 21X datalogger to the station.
- Offload data from the storage module according to the procedure given in section 3.1
- Store the raw data under (GeoBasis\Micrometeorological station\21x\foldername) in a folder called 21X DDMMYY”, where DD=day, MM= month, YY= year.

**Input of data to the local database**

Transfer data from the memory card to the GeoBasis computers harddisc. Save all files under (GeoBasis\Micrometeorological station\Edisol\foldername) in a folder called “Ed DDMMYY”, where Ed= Edisol, DD=day MM=month YY=year. Make two backup CD´s of rawdata.

Files with the extension .flx can be opened in Excel and the average half hour values can be checked. Make a continues diagram of the $CO_2$-concentration and append data files to each other in an Excel file called EdisolYYYY

Write two CD backups of the rawdata. Make an Excell file called 21X YYYY, where the datafiles append to each other.

## 7.6 Preparation for vinter storage

Leave all temperature sensor cables in the datalogger slots and store the sensors in the cupboard. Leave the batteries in their box and seal the box. Store solar panels, cupboard and mast in house number 3. Bring the computer home. Never transport the Li-6262 without filters and make sure, that all tubes are closed/ connected to prevent any open passage into the Li-6262.

## 7.7 Use of generator for additional power supply

- Bring generator, charger and cable out to the station. There is a special wooden box/shelter to shield the generator at the site.
- Place the generator as far away from the mast as your cables allow and in a position where the wind will blow exhaust from the generator in the opposite direction than the air intake on the mast.
- Connect the cable from the generator to the charger box connected to the batteries
- Start the generator and let it run for a few minutes before connecting to the charger.
- Record the time where the generator is running in the field book. Normally the generator will run for c. 4 hours on a full tank.

# 8 Geomorphological monitoring

Se 1995 Zero rapporten.

## 8.1 Coastal dynamics

**Parameters to be measured**
Coastal cliff reccesion
Topographic changes at two cross shore profiles
Wetland sedimentation rate
Photo monitoring of characteristic landforms

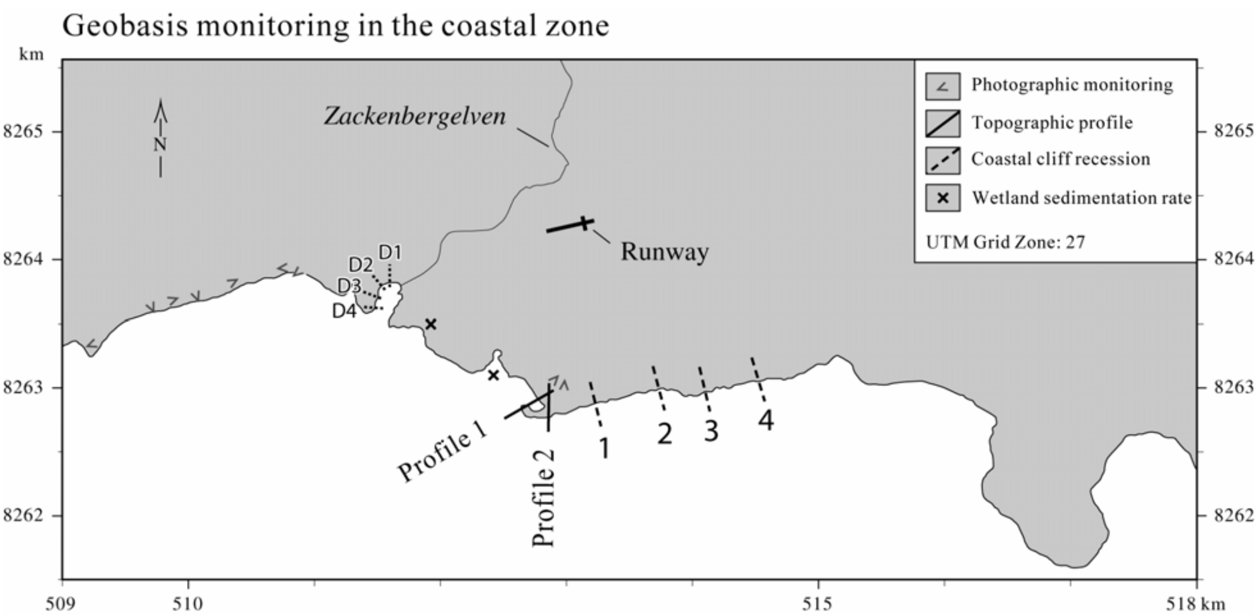



**Fig 8.1** Map showing monitoring sites in the coastal zone.

### 8.1.1 Coastal cliff reccesion

Coastal reccesion over time can be surveyed by repeating measurements of the distance between a fixed position and the cliff top

**Location**
Coastal retreat rates are monitored along the south coast of Zackenbergdalen (Coastal cliff) and along the coastal cliff west of the Zackenbergelven river delta (Delta cliff, Fig 8.3). Position of the pegs are given in Table 8.1 and 8.2.

At the coastal cliff wooden pegs with a red spot were installed 20 meter from the top of the cliff in 1996. Behind the peg, a small metal peg can be used for orientation of the line.

| | UTM-position | | |
|---|---|---|---|
| Coastalcliff | Northing | Easting | Year |
| line 1 | 8263013 | 513272 | 1996 |
| line 2 | 8263080 | 513748 | 1996 |
| line 3 | 8263065 | 514026 | 1996 |
| line 4 | 8263125 | 514398 | 1996 |

**Tabel 8.1** Positions of coastal cliff pegs.

| | UTM-position | | |
|---|---|---|---|
| Delta cliff | Northing | Easting | Year |
| line 1 D1 | 8264000 | 511619 | 2000 |
| line 2 D2 | 8264015 | 511524 | 2000 |
| line 3 D3 | 8263865 | 511372 | 2000 |
| line 4 D4 | 8263764 | 511379 | 2000 |

**Tabel 8.2** Positions of delta cliff pegs.

**Fig 8.2** Measurement at the coastal cliff .

At the Delta cliff green metal pegs were installed 20 meter from the top of the cliff in 2000. Behind the peg, a small metal peg can be used for orientation of the line.

**Frequency**

Lines are re-surveyed once a year in late august

**Equipment to be used**

Tape measurer
Peg
GPS
Digital camera

**Fig 8.3** Erosion at the Delta cliff

**Procedure for measuring retreat rates**

- Use the GPS to find the pegs.
- Survey the perpendicular distance from center of the peg to the top of the cliff, using a tape measurer. Behind the woodem peg, a small metal peg can be used for orientation of the line.
- Take a digital photo from the site

**Maintenance**

Paint the pegs once in a while to help recognize them

**Input of data to the local database**

Results are reported and stored in the file „cliff reccesion coast and delta" (GeoBasis\Costal dynamics\cliff reccesion coast and delta).

At the end of the season data from the coastal cliff are reported to Arctic Coastal Dynamics (ACD).
**Contact:**
Dr. habil. Volker Rachold vrachold@awi-potsdam.de

### 8.1.2 Topographic changes at beach profiles

In order to follow the rate of coastal sediment transport two terrain profiles have been re-surveyed every year

**Location**

Location of the profile lines are given in Fig 8.4 and 8.5 and Table 8.3 and 8.4

*Profile 1*

Profile 1 is a c. 250 m long profile line crossing a curved spit near the old delta. The profile is marked by pegs.

| | UTM-position | | | |
|---|---|---|---|---|
| **P1** | **Northing** | **Easting** | **m a.s.l.** | **Marker in the field** |
| P1a | 8262971 | 512861 | 6.39 | Iron peg on gravel plateau |
| P1b | 8262952 | 512830 | 5.12 | Iron peg on gravel plateau |
| P1c | 8262946 | 512816 | | Peg of driftwood |
| P1d | 8262866 | 512668 | 0.98 | Wooden peg, inner barrier |
| P1e | 8262848 | 512633 | 1.12 | Wooden peg, outer barrier |
| P1f | 8262963 | 512823 | | Yellow peg (Photo point) |

**Table 8.3.** Position of the pegs in Profile 1

**Fig 8.4** Looking at the curved spit, Profile 1

*Profile 2*

Profile 2 is a c.140 m long profile in an aggrading coastal plain with beach ridges. The profile is marked by pegs.

| | UTM-position | | | |
|---|---|---|---|---|
| **P2** | **Northing** | **Easting** | **m a.s.l.** | **Marker in the field** |
| P2a | 8262974 | 512899 | 6.13 | Iron peg on gravel plateau |
| P2b | 8262934 | 512904 | | Peg of driftwood |
| P2c | 8262867 | 512914 | 0.99 | Iron peg on beach ramp |
| P2d | 8262959 | 512920 | | Yellow peg (Photo point) |

**Table 8.4.** Position of the pegs in Profile 2

**Fig 8.5** Topographic measurement at the coastal plain, Profile 2.

**Frequency**

Profiles are re surveyed once a year/every second year in late august. Preferrably during low tide

**Equipment to be used**

Total station (Topcon GTS-6)
Extra battery for GTS-6
User manual GTS-6
Stage/Tripod
Prism-rod
GPS
Field chart
Ranging poles
Notebook

Waders
2 VHF-radioes
2 persons
Digital camera

**Procedure for re-survey of topographic profiles**

- Find all pegs in the profile from the UTM coordinates in table 8.3 and 8.4 and in App 4.
- Line up two or three ranging poles in the profile in order to have the line in sight during measurement.
- Set up tripod on the gravel plateau near the beach/coastal cliff. Make sure the instrument is in the profile line and that the total profile can be measured from the same position
- Carefully place the GTS-6 on the tripod. Level the instrument. From this point throughout measurements be EXTREMELY careful not bump or step too closely to tripod legs as instrument will get out of level
- Turn instrument on. Be sure that vertical and horizontal motion clamps (fine focus locks) are loose, and rotate vertically and horizontally several complete turns to clear instrument memory.
- Place the prism on the rod and record the height of the prism rod (could be 2 m)
- Start surveying at a point as far out in the water you can wade safely. Move on along the line toward the total station. Survey all points where the vertical angel of the profile changes. Record remarks about the point in the radio (shore line, in the water, foot of cliff, peg, top of beach ridge....)
- The person in control of the instrument must guide the prism holder to stay in the line and write down distance, height and remarks of the point.
- Place the prism-rod on the pegs and next to the pegs. Record when you pass the station and start to shoot the other way (180 degrees). The profile ends right behind the last peg on the plateau.
- Take photo of the line from the photo point on the plateau.
- Move the station to Profile 2 and follow the same procedure as for profile 1

**Notice.** Never let the instrument get wet. Close down if it start to rain. Never point the instrument direct into the sun. Make sure adjusting knobs are loose when you transport the instrument.

**Input of data to the local database**
Add data into a file and name it: Profile1(or2)ddmmyy and move it to the GeoBasis directory: (GeoBasis\Coastal monitoring\Topographic profiles\Filename)

**Laboratory work**
To be able to compare the topographic profiles adjust the height and length of the profile after the top of the iron peg at the plateau. For profile 1 use P1b=5.12 m a.s.l. and set the length to 0 m at that peg (table 8.3). For profile 2 use P2a=6.13 m a.s.l. and set the length to 0 m at that peg (table8.4).

### 8.1.5 Topographic measurements  in the Zackenberg river

**-This section is under construction and further details will be given in the next edition**

**Location**

**Frequency**
The cross profile at the river crossing site are re-surveyed once a year.

**Equipment to be used**

**Procedure**

## 8.2 Landscape dynamics/ Quantitative

**-This section is under construction and further details will be given in the next edition**

### 8.2.1 Solifluction rates
The rate of movement for solifluction lobes are measured at two sites in Zackenbergdalen. At one site a cross profile of pegs with a short distance were arranged parallel to direction of flow and at the other site a cross profile of pegs were arranged perpendicular to the direction of flow. This allows studying of the differential movement of the lobe. Se 1996 rapport

**Location**
SL 1:
UTM: 8264053 mN, 512365 mE
Elevation:

SL2:
UTM: 8263885 mN, 51571 mE
Elevation:

SL3:
UTM: Ude ved Ulvehøj
Elevation:

**Frequency**

**Equipment to be used**

**Fig 8.6** Sulifluction lobe just south of the Zackenberg station.

### 8.2.3 Ice wedge growth

For rate of ice wedge growth a measuring net was established in 1995. At each site 6 fixed pegs are positione as shown in Fig XX, enabling the distance across the ice wedge to be measured accurately at three positions

**Location**
IW 1: Marked by yellow pegs
UTM: 8264359 mN, 512670 mE
Elevation:

IW 2:
UTM: 8264109 mN, 512624 mE
Elevation:

IW 3:
UTM: 8263464 mN, 512310 mE
GeoBasis 2004/ photo/geomorphology
Elevation:

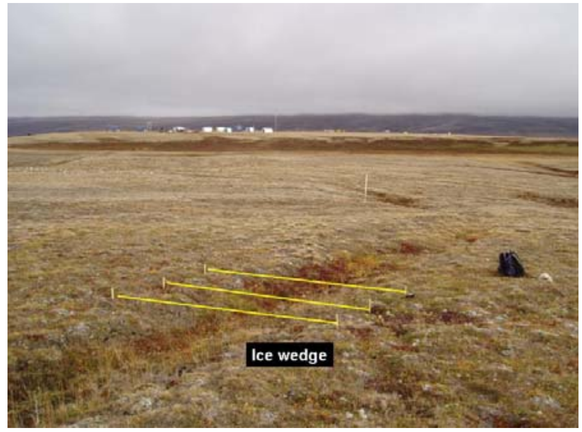



**Fig 8.7** Ice wedge south of Zackenberg station. Distance between pegs are measured at three lines.

**Frequency**
**Equipment to be used**

## 8.2.4 Salt marsch accretion

Wetland sedimentation rate are measured at two sites. Hvordan måles det. Hvem har startet det??

SM 1:
UTM: 8263363 mN, 512415 mE
Elevation:

Billeder/photomonitering/8220013

**Frequency**
**Equipment to be used**


**Fig 8.9** Site for monitoring salt marsch accretion.

## 8.2.5 Wind abrasion

The rate of wind abrasion is monitored at a site clearly influenced by the northerly winds. A test site consisting of eight non polished small boulders was established in 1995. The non polished stones were positioned on a line extending east-west. On the side of the stone facing towards north an area of 10 x 10 cm has been completely covered by yellow painting. The wind will remove the painting in areas and eventually the stone will become windpolished. In this way it will be possible to examine how fast wind abrasion will develop on stones of different lithology.

WA 1:
UTM: 8268397 mN, 511090mE
Elevation:

**Frequency**

**Equipment to be used**

## 8.3 Landscape dynamics/ Photomonitoring

A total of 24 photo monitoring sites of different landscape elements are included in the programme, in order to follow geomorphological changes. The landscape elements are all expected to change in a short time scale (< 10 years).

**Frequency**

Some photos are recaptured once a year and some every second year. Details are given along with each photo.

**Equipment to be used**

Digital camera
Map of positions
GPS
Sample of all photos

**Snow patches/Nivation**

Several nivation hollows containing either seasonal or perennial snowpatches are being monitored, in order to detect changes in form, vegetational zonation and the annual summer minimum size of the snowpatches.

**Talus slopes**

Especially along the north west, north and northeast facing slopes in Zackenbergdalen talus slopes are widespread. To measure rockfall activity.

**Thermokarst development**

Erosion due to melting of the permafrost take place several places in the valley.

**Debris islands**

At two places photos of debris islands are captured in order to determine the rate of movement. Spørg Ole og Hanne hvordan de billeder skal tages.

**Rock glaciers**

Several rock glaciers are found in the greater Zackenberg research area lining the foot of talus slopes or originating within cirques.

**Free rock faces**

Changes regarding surface form and colour, indicating recent rock fall will be registered in this way. Accumulation of rock fragments

**Avalanche tracks**

Several talus slopes in the area are influenced by snow avalanches. Avalanche boulder tongues are being monitored

# APPENDIX 2

## FIELD CHARTS

## GEOBASIS

| Field chart 1 | | | | Manual Snow depth measurements | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Description of site** | **Site ID** | **UTM Northing** | **UTM Easting** | **Sampler** | **Date** | **Time** | **Snow depth (cm)** | | | | | **Remarks** |
| | | | | | | | **1** | **2** | **3** | **4** | **5** | |
| Hydrometric station | St 0 | 8264596 | 512605 | | | | | | | | | |
| M2 | St 1 | 8264501 | 512748 | | | | | | | | | |
| Stake 2 | St 2 | 8263902 | 513648 | | | | | | | | | |
| Stake 3 | St 3 | 8264686 | 513471 | | | | | | | | | |
| Climate station snow mast | St 4 | 8264774 | 513380 | | | | | | | | | |
| Stake 5 | St 5 | 8266089 | 513538 | | | | | | | | | |
| Stake 6 | St 6 | 8267092 | 513641 | | | | | | | | | |
| M3 | St 7 | 8269870 | 517503 | | | | | | | | | |
| | | | | | | | | | | | | |
| Soil water site | Dry-2 | 8265563 | 513365 | | | | | | | | | |
| Soil water site | Dry-1 | 8265045 | 513816 | | | | | | | | | |
| Soil water site | Sal-2 | 8264692 | 513623 | | | | | | | | | |
| Soil water site | Sal-1 | 8264649 | 513045 | | | | | | | | | |
| Soil water site | Mix1 | 8264348 | 513567 | | | | | | | | | |
| Soil water site | K2 | 8264760 | 513365 | | | | | | | | | |
| Soil water site | K3 | 8264753 | 513349 | | | | | | | | | |
| Soil water site | S2 | 8263950 | 513016 | | | | | | | | | |
| Soil water site | S3 | 8263950 | 513016 | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| Corner in ZC-1 | 1NW | 8264856 | 513363 | | | | | | | | | |
| Corner in ZC-1 | 1NE | 8264847 | 513461 | | | | | | | | | |
| Corner in ZC-1 | 1SE | 8264748 | 513446 | | | | | | | | | |
| Corner in ZC-1 | 1SW | 8264758 | 513347 | | | | | | | | | |
| | | | | | | | | | | | | |
| Corner in ZC-2 | 2NW | 8264083 | 513025 | | | | | | | | | |
| Corner in ZC-2 | 2NE | 8264033 | 513167 | | | | | | | | | |
| Corner in ZC-2 | 2SE | 8263920 | 513127 | | | | | | | | | |
| Corner in ZC-2 | 2SW | 8263970 | 512985 | | | | | | | | | |
| | | | | | | | | | | | | |

| Field chart 2 | | | | | Snow Water Equivalent (SWE) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Site** | **UTM Northing** | **UTM Easting** | **Sampler** | **Date** | **Time** | **Snow depth (cm)** | **Length of core (cm)** | **Weight of tube and core (kg)** | **Weight of empty tube (kg)** | **Remarks** |
| In ZC-1 | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| Snow patch in ZC-2 | | | | | | | | | | |
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| Adjacent to stake 2 | | | | | | | | | | |
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| Adjacent to stake 3 | | | | | | | | | | |
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| Adjacent to stake 5 | | | | | | | | | | |
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| Adjacent to stake 6 | | | | | | | | | | |
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**Field chart 3** **Logbook : Camera**

| Date | Time | Timer | Voltage | Sampler | Offloaded photos | Days since last off loading | Remarks |
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| 4 | ZEROCALM-1 Active layer depth |
|---|---|

**Date**

**Time**

**Initials of Surveyor**

**Remarks**

**Location**

| Corner | Northing | Easting |
|---|---|---|
| **NW** | **8264856** | **513363** |
| **SW** | **8264758** | **513347** |
| **NE** | **8264847** | **513461** |
| **SE** | **8264748** | **513446** |

**NW** **NE**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **11** | | | | | | | | | | | |
| **10** | | | | | | | | | | | |
| **9** | | | | | | | | | | | |
| **8** | | | | | | | | | | | |
| **7** | | | | | | | | | | | |
| **6** | | | | | | | | | | | |
| **5** | | | | | | | | | | | |
| **4** | | | | | | | | | | | |
| **3** | | | | | | | | | | | |
| **2** | | | | | | | | | | | |
| **1** | | | | | | | | | | | |
| **Y/X** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** |

**SW** **SE**

It is important that all measurements are made to the soil surface and read with an accuracy of one centimeter.

# 5 ZEROCALM-2 Active layer depth

**Location**

| Corner | Northing | Easting |
|---|---|---|
| **NW** | **8264083** | **513025** |
| **NE** | **8264033** | **513167** |
| **SE** | **8263920** | **513127** |
| **SW** | **8263970** | **512985** |

**Date**

**Time**

**Initials of Surveyor**

**Remarks**

**NW** **NE**

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **13** | | | | | | | | | | | | | | | | |
| **12** | | | | | | | | | | | | | | | | |
| **11** | | | | | | | | | | | | | | | | |
| **10** | | | | | | | | | | | | | | | | |
| **9** | | | | | | | | | | | | | | | | |
| **8** | | | | | | | | | | | | | | | | |
| **7** | | | | | | | | | | | | | | | | |
| **6** | | | | | | | | | | | | | | | | |
| **5** | | | | | | | | | | | | | | | | |
| **4** | | | | | | | | | | | | | | | | |
| **3** | | | | | | | | | | | | | | | | |
| **2** | | | | | | | | | | | | | | | | |
| **1** | | | | | | | | | | | | | | | | |
| **Y/X** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** |

**SW** **SE**

It is important that all measurements are made to the soil surface and read with an accuracy of one centimeter.

# Field chart 6: Water discharge in the Zackenberg river

**Date (DDMMYY):**

**Time (start):** **Time (end):**

**Water level (start):** **Water level (end):**

**Distance from fixed point to shore line:**

**Type of current meter and digit counter:**

**Name of Surveyors:**

**Comments (ice and snow drift or along the shoreline or the river bed):**

**Photo:**

| Distance to shore (m) | Water depth (cm) | Rotations per 50 (100) sec | Velocity (m/s) | Discharge (m3/s) |
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| Field chart 7 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Water samples** | | | | | | | | | | |
| Date (DDMMYY) | | | | | | | | | | |
| Time (HH:MM) | | | | | | | | | | |
| Position | | | | | | | | | | |
| Initials of sampler | | | | | | | | | | |
| Comments<br>(Colour, sediment, ice drift, snow on the shore…) | | | | | | | | | | |
| **Measurements in the river** | | | | | | | | | | |
| Stage water level (cm) | | | | | | | | | | |
| Water temperature (°C) | | | | | | | | | | |
| Conductivity (µS/cm) | | | | | | | | | | |
| Specific conductivity (25 °C) (µS/cm) | | | | | | | | | | |
| **Analysis in Zackenberg** | | | | | | | | | | |
| pH | | | | | | | | | | |
| Volume for alcalinity test (g) | | | | | | | | | | |
| Volume of added HCl (ml) | | | | | | | | | | |
| Concentration of added HCl (M) | | | | | | | | | | |
| Label on filtered sample (DDMMYY-HH) | | | | | | | | | | |
| | | | | | | | | | | |
| **Suspended sediment** | **1** | **2** | **1** | **2** | **1** | **2** | **1** | **2** | **1** | **2** |
| Label on sediment filter (DDMMYY-HH - 1 or (2)) | | | | | | | | | | |
| | | | | | | | | | | |
| Weight of filter (g) | | | | | | | | | | |
| Weight of bottle and water sample (g) | | | | | | | | | | |
| Weight of empty bottle (g) | | | | | | | | | | |
| Weight of filter+sediment after drying at 105°C (g) | | | | | | | | | | |

## Field chart 8

**Site ID**

| Date | Time | Depth | Soil moist | Act.layer | Date | Time | Depth | Soil moist | Act.layer |
|---|---|---|---|---|---|---|---|---|---|
| (DDMMYY) | (HH:MM) | (cm) | (vol%) | (cm) | (DDMMYY) | (HH:MM) | (cm) | (vol%) | (cm) |
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| Field chart 9 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Soil water** | | | | | | | |
| Site ID | | | | | | | |
| Depth (cm) | | | | | | | |
| Initials of surveyor | | | | | | | |
| **Application of vacuum** | | | | | | | |
| Date (DDMMYY) | | | | | | | |
| Time (HH:MM) | | | | | | | |
| Date (DDMMYY) | | | | | | | |
| Time (HH:MM) | | | | | | | |
| Date (DDMMYY) | | | | | | | |
| Time (HH:MM) | | | | | | | |
| Depth of active layer (cm) (avg of 5 points) | | | | | | | |
| **Collection of sample** | | | | | | | |
| Date (DDMMYY) | | | | | | | |
| Time (HH:MM) | | | | | | | |
| Water volume (g) | | | | | | | |
| pH (field) | | | | | | | |
| Comments (colour, precipitates…) | | | | | | | |
| **Analysis in Zackenberg** | | | | | | | |
| pH (lab) | | | | | | | |
| Conductivity (µS/cm) | | | | | | | |
| Temperature (°C) | | | | | | | |
| Volume for alcalinity test (g) | | | | | | | |
| Volume of added HCl (ml) | | | | | | | |
| Concentration of added HCl (M) | | | | | | | |
| Label on samples (ID-DDMMYY-CM) | | | | | | | |

# 10 Eddy correlation mast, heath-site, Zackenberg

**Date** Calender date:__________________ DOY:___________________

**Time** Datalogger21X:____________Computer:__________ Observer:________________

**Licor**: $CO_2$-concentration (µmol/mol = ppm) **(1)** :_________________________

$H_2O$-concentration (mmol/mol = ppt) **(1)** :_________________________

LI-COR pressure (kPa) **(2)**: __________________________

Temperature (°C) **(2)** :_________________________

**Edisol** $CO_2$-concentration (µmol/mol = ppm) **(calibrated)** :_________________________

$H_2O$-concentration (µmol/mol = ppt) **(calibrated)** :_________________________

$CO_2$-flux (µmolm$^{-2}$s$^{-1}$) **(Fc)** :_________________________

QE ($H_2O$-flux) (W m$^{-2}$) **(LE)** :_________________________

QH (Temperature-flux) (W m$^{-2}$) **(SonicH)** :_________________________

U (Wind speed) (m s$^{-1}$) :________________________

Sonic Temperature (°C) **(calibrated)** :________________________

**Weather report** (clouds, precipitation, snow cover….)

Wind direction:_______________________ Visibility:_________________________

Battery-voltage: 21X:___________V Batteries in the box:____________V

**Comments:**

# 11 Micro meteorological station

| Date | Change Chemicals | Calibration | Change Filter | Check | Data retrieval | Back up |
|---|---|---|---|---|---|---|
| | 1 weekly | 1 per 3rd week | S:1 weekly.<br>R:1 monthly | Daily | 1 weekly | 1 weekly |
| 1/ | | | | | | |
| 2/ | | | | | | |
| 3/ | | | | | | |
| 4/ | | | | | | |
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| 31/ | | | | | | |

| Field chart 12 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Water samples from streams** | | | | | | | | |
| Date (DDMMYY) | | | | | | | | |
| Time (HH:MM) | | | | | | | | |
| Position | **RS-1: Store Sødal** | **RS-2: Lindeman** | **RS-3: PalnatokeNW** | **RS-4: PalnatokeE** | **RS-5: AucellaN** | **RS-6:AucellaS** | **RS-7: Rylekær** | **RS-8: Tørvekær** |
| Initials of sampler | | | | | | | | |
| Comments<br>(Colour, sediment, ice drift, size…) | | | | | | | | |
| **Measurements in the river** | | | | | | | | |
| pH | | | | | | | | |
| Water temperature (°C) | | | | | | | | |
| Conductivity (µS/cm) | | | | | | | | |
| Specific conductivity (25 °C) (µS/cm) | | | | | | | | |
| **Analysis in Zackenberg** | | | | | | | | |
| pH | | | | | | | | |
| Volume for alcalinity test (g) | | | | | | | | |
| Volume of added HCl (ml) | | | | | | | | |
| Concentration of added HCl (M) | | | | | | | | |
| Label on filtered sample (RS#DDMMYY) | | | | | | | | |
| | | | | | | | | |
| **Suspended sediment** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |
| Label on sediment filter (RS#DDMMYY) | | | | | | | | |
| | | | | | | | | |
| Weight of filter (g) | | | | | | | | |
| Weight of bottle and water sample (g) | | | | | | | | |
| Weight of empty bottle (g) | | | | | | | | |
| Weight of filter+sediment after drying at 105°C (g) | | | | | | | | |

# APPENDIX 3

## Instrumentation of installations

## GEOBASIS

## APPENDIX 3

Instrumentation of GeoBasis and ClimateBasis installations.

### Tabel 1 Climate station, snow mast (st. 644)

| Log | Parameter | Unit | Instrumentation | Model | Manufacturer | Elevation |
|---|---|---|---|---|---|---|
| 3 hour | Soil Temperature | °C | Temperature probe | 107 thermistor | Campbell Scientific | 0 cm |
| 3 hour | AirTemperature | °C | Temperature probe | 107 thermistor | Campbell Scientific | 167 cm |
| 3 hour | Snow depth | meter | Sonic Range Sensor | SR50 | Campbell Scientific | 167 cm |
| 3 hour | Battery power | Volt | | | | |

### Tabel 2 Micrometeorological station (M2)

| Log | Parameter | Unit | Instrumentation | Model | Manufacturer | Elevation |
|---|---|---|---|---|---|---|
| 30 min | Battery | Volt | | | | |
| 30 min | Program signal | | | | | |
| 30 min | InternalTemp | °C | | | | |
| 30 min | Panel Temp | °C | | | | |
| 30 min | Gust | m/sec | Windvane | A100R | Campbell Scientific | 250 cm |
| 30 min | Wind Speed | m/sec | Windvane | A100R | Campbell Scientific | 250 cm |
| 30 min | Wind Direction | ° | Windvane | W200P | Campbell Scientific | 250 cm |
| 30 min | Wind Direction | St.Dev. | Windvane | W200P | Campbell Scientific | 250 cm |
| 30 min | Rel. Hum. | % | Temp and Rel hum probe | MP103A | Campbell Scientific | 250 cm |
| 30 min | Air Temperature | °C | Temp and Rel hum probe | MP103A | Campbell Scientific | 250 cm |
| 30 min | SoilTemperature | °C | Thermocouple | 105T Type T | Campbell Scientific | 0 cm |
| 30 min | SoilTemperature | °C | Thermocouple | 105T Type T | Campbell Scientific | -10 cm |
| 30 min | SoilTemperature | °C | Thermocouple | 105T Type T | Campbell Scientific | -30 cm |
| 30 min | SoilTemperature | °C | Thermocouple | 105T Type T | Campbell Scientific | -60 cm |
| **6 hour** | Soil moisture | % | Soil moisture probe | Theta-ML2x | Delta-T Cambridge, UK | -10 cm |
| **6 hour** | Soil moisture | % | Soil moisture probe | Theta-ML2x | Delta-T Cambridge, UK | -30 cm |
| **6 hour** | Snow Depth | Cm | Sonic range sensor | SR50 | Campbell Scientific | 247 cm |
| 30 min | Red 660 | | Skye radiation sensor | SKR110 | SKYE | 250 cm |
| 30 min | NIR | | Skye radiation sensor | SKR110 | SKYE | 250 cm |
| 30 min | RVI | | Skye radiation sensor | SKR110 | SKYE | 250 cm |
| 30 min | NDVI | | Skye radiation sensor | SKR110 | SKYE | 250 cm |
| 30 min | SoilHeat | W/m2 | Heat flux plate | HTF3 | | -1 cm |
| 30 min | Si | W/m2 | Met radiometer | CNR1 | Kipp & Zonen | 250 cm |
| 30 min | Su | W/m2 | Met radiometer | CNR1 | Kipp & Zonen | 250 cm |
| 30 min | Li | W/m2 | Met radiometer | CNR1 | Kipp & Zonen | 250 cm |
| 30 min | Lu | W/m2 | Met radiometer | CNR1 | Kipp & Zonen | 250 cm |
| 30 min | CNR1 Temp | °C | Met radiometer | CNR1 | Kipp & Zonen | 250 cm |
| 30 min | Net Rs | W/m2 | | | | |
| 30 min | Net Ri | W/m2 | | | | |
| 30 min | Albedo | % | | | | |
| 30 min | Net Rad | W/m2 | | | | |
| 30 min | Li cor | W/m2 | | | | |
| 30 min | Lu cor | W/m2 | | | | |
| 30 min | Temp Skye | °K | | | | |
| 30 min | Temp Ground | °K | | | | |

### Tabel 3 Micrometeorological station (M3)

| Log | Parameter | Unit | Instrumentation | Model | Manufacturer | Elevation |
|---|---|---|---|---|---|---|
| 30 min | Battery | Volt | | | | |
| 30 min | Program signal | | | | | |
| 30 min | InternalTemp | °C | | | | |
| 30 min | Panel Temp | °C | | | | |
| 30 min | Gust | m/sec | Windvane | A100R | Campbell Scientific | 200 cm |
| 30 min | Wind Speed | m/sec | Windvane | A100R | Campbell Scientific | 200 cm |
| 30 min | Wind Direction | ° | Windvane | W200P | Campbell Scientific | 200 cm |
| 30 min | Wind Direction | St.Dev. | Windvane | W200P | Campbell Scientific | 200 cm |
| 30 min | Rel. Hum. | % | Temp and Rel hum probe | MP103A | Campbell Scientific | 200 cm |
| 30 min | Air Temperature | °C | Temp and Rel hum probe | MP103A | Campbell Scientific | 200 cm |
| 30 min | SoilTemperature | °C | Thermocouple | 105T Type T | Campbell Scientific | 0 cm |
| 30 min | SoilTemperature | °C | Thermocouple | 105T Type T | Campbell Scientific | -10 cm |
| 30 min | SoilTemperature | °C | Thermocouple | 105T Type T | Campbell Scientific | -30 cm |
| 30 min | SoilTemperature | °C | Thermocouple | 105T Type T | Campbell Scientific | -60 cm |
| **6 hour** | Soil moisture | % | Soil moisture probe | Theta-ML2x | Delta-T Cambridge, UK | -10 cm |

| Log | Parameter | Unit | Instrumentation | Model | Manufacturer | Elevation |
|---|---|---|---|---|---|---|
| 6 hour | Soil moisture | % | Soil moisture probe | Theta-ML2x | Delta-T Cambridge, UK | -30 cm |
| 6 hour | Snow Depth | Cm | Sonic range sensor | SR50 | Campbell Scientific | 188 cm |
| 30 min | Red 660 | µmol/m | Skye radiation sensor | SKR110 | SKYE | 200 cm |
| 30 min | NIR | | Skye radiation sensor | SKR110 | SKYE | 200 cm |
| 30 min | RVI | | Skye radiation sensor | SKR110 | SKYE | 200 cm |
| 30 min | NDVI | | Skye radiation sensor | SKR110 | SKYE | 200 cm |
| 30 min | SoilHeat | W/m2 | Heat flux plate | HTF3 | | -1 cm |
| 30 min | Si | W/m2 | Net radiometer | CNR1 | Kipp & Zonen | 200 cm |
| 30 min | Su | W/m2 | Net radiometer | CNR1 | Kipp & Zonen | 200 cm |
| 30 min | Li | W/m2 | Net radiometer | CNR1 | Kipp & Zonen | 200 cm |
| 30 min | Lu | W/m2 | Net radiometer | CNR1 | Kipp & Zonen | 200 cm |
| 30 min | CNR1 Temp | °C | Net radiometer | CNR1 | Kipp & Zonen | 200 cm |
| 30 min | Net Rs | W/m2 | | | | |
| 30 min | Net Ri | W/m2 | | | | |
| 30 min | Albedo | % | | | | |
| 30 min | Net Rad | W/m2 | | | | |
| 30 min | Li cor | W/m2 | | | | |
| 30 min | Lu cor | W/m2 | | | | |
| 30 min | Temp Skye | °K | | | | |
| 30 min | Temp Ground | °K | | | | |

## Tabel 4 Climate station, East mast (st. 640)

| Log | Parameter | Unit | Instrumentation | Model | Manufacturer | Elevation |
|---|---|---|---|---|---|---|
| 10 min. | WindSpeed avg | m/s | Anemometer | 4033 | Th. Friedrichs & Co | 200 cm |
| 10 min. | WindSpeed max | m/s | Anemometer | 4033 | Th. Friedrichs & Co | 200 cm |
| 60 min | PAR | µmol/m2/s | PAR sensor | Quantum, LI-190S | LI-COR, Nebraska, USA) | 200 cm |
| 60 min | Battery power | Volt | | | | |
| 60 min | Soil temperature | °C | Thermistor | PT100 | Frode Pedersen | -2,5 cm |
| 60 min | Soil temperature | °C | Thermistor | PT100 | Frode Pedersen | -10 cm |
| 60 min | Soil temperature | °C | Thermistor | PT100 | Frode Pedersen | -40 cm |
| 60 min | Soil temperature | °C | Thermistor | PT100 | Frode Pedersen | -80 cm |
| 60 min | Soil temperature | °C | Thermistor | PT100 | Frode Pedersen | -130 cm |
| 60 min | Air temperature 1 | °C | Temp and Rel hum probe | HMP35 | Vaisala | 200 cm |
| 60 min | Air temperature 2 | °C | Temp and Rel hum probe | HMP35 | Vaisala | 750 cm |
| 60 min | Air temperature 3 (with fa | °C | Temp and Rel hum probe | HMP35 | Vaisala | 200 cm |
| 60 min | Rel. Humidity 1 | % | Temp and Rel hum probe | HMP35 | Vaisala | 200 cm |
| 60 min | Rel. Humidity 2 | % | Temp and Rel hum probe | HMP35 | Vaisala | 750 cm |
| 60 min | Rel Humidity 3 (with fan) | % | Temp and Rel hum probe | HMP35 | Vaisala | 200 cm |
| 60 min | Netto Radiation | W/m2 | Net radiometer | CM7 | Kipp & Zonen | 200 cm |
| 60 min | Rad in | W/m2 | Net radiometer | CM7 | Kipp & Zonen | 200 cm |
| 60 min | Rad out | W/m2 | Net radiometer | CM7 | Kipp & Zonen | 200 cm |
| 60 min | Air Pressure | hPa | Digital barometer | PTB200A | Vaisala | 200 cm |
| Event | Precipitation | cm | Tipping bucket | 444C | Handar | 200 cm |

## Tabel 5 Climate station, West mast (st. 641)

| Log | Parameter | Unit | Instrumentation | Model | Manufacturer | Elevation |
|---|---|---|---|---|---|---|
| 10 min | Wind Speed 1 | m/s | Anemometer | 4033 | Th. Friedrichs & Co. | 750 cm |
| 10 min | Wind Direction | ° , from magnetic | Anemometer | 4033 | Th. Friedrichs & Co. | 750 cm |
| 10 min | Wind Speed 1, max | m/s | Anemometer | 4033 | Th. Friedrichs & Co. | 750 cm |
| 10 min | Wind direction, max | ° , from magnetic | Anemometer | 4033 | Th. Friedrichs & Co. | 750 cm |
| 10 min | Wind Speed 2, avg | m/s | Anemometer | 4033 | Th. Friedrichs & Co. | 200 cm |
| 10 min | Wind Speed 2, max | m/s | Anemometer | 4033 | Th. Friedrichs & Co. | 200 cm |
| 10 min | AirTemperature 2, avg | °C | Temp and Rel hum probe | HMP35 | | 200 cm |
| 10 min | Rel Humidity 2, avg | % | Temp and Rel hum probe | HMP35 | | 200 cm |
| 60 min | Battery | Volt | | | | |
| 60 min | Soil Temperature | °C | Thermistor | PT100 | Frode Pedersen | 0 cm |
| 60 min | Soil Temperature | °C | Thermistor | PT100 | Frode Pedersen | -5 cm |
| 60 min | Soil Temperature | °C | Thermistor | PT100 | Frode Pedersen | -20 cm |
| 60 min | Soil Temperature | °C | Thermistor | PT100 | Frode Pedersen | -60 cm |
| 60 min | Soil Temperature | °C | Thermistor | PT100 | Frode Pedersen | -100 cm |
| 60 min | Air temperature | °C | Temp and Rel hum probe | HMP35 | | 200 cm |
| 60 min | Rel. Humidity 1 | %RH | Temp and Rel hum probe | HMP35 | | 200 cm |
| 60 min | UVBx5 85 | mW/m2 | Biometer | 501A | Solar Light & Co. | 200 cm |

| Log | Parameter | Unit | Instrumentation | Model | Manufacturer | Elevation |
|---|---|---|---|---|---|---|
| 60 min | Temp UVB | °C | Biometer | 501A | Solar Light & Co. | 200 cm |
| 60 min | Rad in | W/m2 | Radiometer | CM7B | Kipp & Zonen | 200 cm |
| 60 min | Rad out | W/m2 | Radiometer | CM7B | Kipp & Zonen | 200 cm |
| 60 min | Precipitation | mm | Precipitation gauge | Belfort | | 150 cm |
| 60 min | Air Pressure | hPa | Digital barometer | PTB200A | Vaisala | 200 cm |

## Tabel 6 Hydrometric station (st. 642)

| Log | Parameter | Unit | Instrumentation | Model | Manufacturer | Elevation |
|---|---|---|---|---|---|---|
| 15 min | Air Temperature | °C | Temperature probe | 107 | Campbell Scientific | 240 cm |
| 15 min | WaterLevel1 | cm | Pressure transducer | PDCR830 | Druck | ? |
| 15 min | WaterLevel 2 | meter | Pressure transducer | PMP4030 | Druck | ? |
| 15 min | WaterLevel 3 | meter | Pressure transducer | | Druck, xxx ? | ? |
| 15 min | WaterDepth | meter | Sonic range sensor | SR50 | Campbell Scientific | 225 cm |
| 15 min | WaterTemperature1 | °C | Conductivity meter | CS547A | | - |
| 15 min | WaterTemperature 2 | °C | Temperature probe | PT100 | Frode Pedersen, PT100 | ? |
| 15 min | WaterTemperature 3 | °C | Temperature probe | PT100 | Frode Pedersen, PT100 | ? |
| 15 min | Conductivity, uncorr. | mS | Conductivity meter | CS547A | | |
| 15 min | Conductivity Tempcorr. | mS | Conductivity meter | CS547A | | |
| 60 min | Logger Temperature | °C | | | | |
| 60 min | Battery Power | Volt | | | | |

## Tabel 7 TDR station (Hasholt)

| Log | Parameter | Unit | Instrumentation | Model | Manufacturer | Elevation |
|---|---|---|---|---|---|---|
| 3 hour | Soil moisture | | | | | -10 cm |
| 3 hour | Soil moisture | | | | | -20 cm |
| 3 hour | Soil moisture | | | | | -30 cm |
| 3 hour | Soil moisture | | | | | -40 cm |
| 3 hour | Soil moisture | | | | | -50 cm |
| 3 hour | Soil moisture | | | | | -60 cm |
| 3 hour | Soil temperature | °C | | | | -10 cm |
| 3 hour | Soil temperature | °C | | | | -20 cm |
| 3 hour | Soil temperature | °C | | | | -30 cm |
| 3 hour | Soil temperature | °C | | | | -40 cm |
| 3 hour | Soil temperature | °C | | | | -50 cm |
| 3 hour | Soil temperature | °C | | | | -60 cm |
| | | | Techtronix | 1502B | | |

**Tabel 8 Micrometeorological station (M1)**

| Log | Parameter | Unit | Instrumentation | Model | Manufacturer | Elevation |
|---|---|---|---|---|---|---|
| 30 min | Sensible heat flux (Qh) | W/m2 | Soil heat flux plate | HFT3 | Campbell Scientific | |
| 30 min | Latent heat flux (Qe) | W/m2 | | | | |
| 30 min | Flux CO2 | µmol/m2/s | | | | |
| 30 min | Carbon dioxide | ppm | Infrared gasanalyzer | LI-6262 | LI-COR, Nebraska, USA) | 300 cm |
| 30 min | Water vapour density | g/m3 | Infrared gasanalyzer | LI-6262 | LI-COR, Nebraska, USA) | 300 cm |
| 30 min | Temperature Sonic | °C | | | | |
| 30 min | 3D Windspeed | m/s | 3D sonic anemometer | Solent 1012R2 | Gill Instruments, Lymingtor | 300 cm |
| 30 min | Wind direction | ° | | | | |
| | Friction velocity | m/s | | | | |
| | | | Accumulators | 83085 12V/85 Ah | Varta | |
| 30 min | IR surface canopy tempe | °C | IR termo | KT-17 | Heimann, Germany | 100 cm |
| 30 min | Soil moisture | vol% | Soil moisture sensor | ML1 | Delta-T Cambridge, UK | 0 to -6 cm |
| 30 min | Soil temperature | °C | Thermocouples | | | -10 cm |
| 30 min | Soil temperature | °C | Thermocouples | | | -3 cm |
| 30 min | Heat flux | W/m2 | Soil heat flux plate | HFT3 | Campbell Scientific | -1 cm |
| 30 min | 21X temp | °C | | | | |
| 30 min | Battery | V | | | | |
| 30 min | Par in | W/m2 | | | | |
| 30 min | Par out | W/m2 | | | | |
| 30 min | NIR in | W/m2 | | | | |
| 30 min | NIR out | W/m2 | | | | |
| 30 min | Si | W/m2 | | | | |
| 30 min | Su | W/m2 | | | | |

| Log | Parameter | Unit | Instrumentation | Model | Manufacturer | Elevation |
|---|---|---|---|---|---|---|
| 30 min | RED | µmol/m | | | | |
| 30 min | NIR | µmol/m | | | | |
| 30 min | UVB | W/m2 | | | | |
| 30 min | Rn | W/m2 | | | | |
| 30 min | Bat | Volt | | | | |
| 30 min | Pan temp | °C | | | | |
| 30 min | PAR r | % | | | | |
| 30 min | NIR r | % | | | | |
| 30 min | Albedo | % | | | | |

# APPENDIX 4

## GPS positions

## GEOBASIS

## GPS positions in Zackenberg

GPS positions of all GeoBasis and ClimateBasis installations. UTM zone 27

| Monitoring site | ID | Northing, mN | Easting, mE | Elev. m a.s.l. | Marking |
|---|---|---|---|---|---|
| **Photomonitoring** | M1 | 8268397 | 511090 | | |
| | M2 | 8268397 | 511090 | | |
| | M3 | 8268397 | 511090 | | |
| | M4 | 8269657 | 516581 | | |
| | M5a | 8264466 | 512701 | | |
| | M5b | 8264466 | 512701 | | |
| | M6 | 8264242 | 512557 | | |
| | M7 | 8263606 | 512710 | | |
| | M8 | 8264017 | 510715 | | |
| | M9 | 8263199 | 512240 | | |
| | M10 | 8263788 | 510124 | | |
| | M11 | 8263742 | 509925 | | |
| | M12 | 8269069 | 516217 | | |
| | M13 | 8269657 | 516581 | | |
| | M14 | 8269902 | 518023 | | |
| | M15 | 8269902 | 518023 | | |
| | M16 | 8264368 | 514516 | | |
| | M17 | 8263066 | 512835 | | |
| | M18 | 8263583 | 512484 | | |
| | M19a | 8264466 | 512016 | 28 | Yellow peg |
| | M19b | 8264466 | 512016 | 28 | |
| | M20 | 8265632 | 513218 | | |
| | M21 | 8264757 | 513682 | | |
| | M22 | 8264838 | 511035 | | |
| | M23 | 8266881 | 513494 | 85 | |
| | M24 | 8265391 | 513153 | 40 | |
| | M25 | 8264664 | 513378 | 45 | |
| | M26 | | | | |
| **Profile 1** | P1a | 8262971 | 512861 | | Iron peg on gravel plateau |
| | P1b | 8262952 | 512830 | | Iron peg on gravel plateau |
| | P1c | 8262946 | 512816 | | Peg of driftwood |
| | P1d | 8262866 | 512668 | | Wooden peg, inner barrier |
| | P1e | 8262848 | 512633 | | Wooden peg, outer barrier |
| | P1f | 8262963 | 512823 | | Yellow peg (Photo point) |
| **Profile 2** | P2 a | 8262974 | 512899 | | Iron peg on gravel plateau |
| | P2 b | 8262934 | 512904 | | Peg of driftwood |
| | P2 c | 8262867 | 512914 | | Iron peg on beach ramp |
| | P2 d | 8262959 | 512920 | | Yellow peg (Photo point) |
| **Coastal cliff** | L1 | 8263013 | 513272 | | Wooden peg, red top |
| | L2 | 8263080 | 513748 | | Wooden peg, red top |
| | L3 | 8263065 | 514026 | | Wooden peg, red top |
| | L4 | 8263125 | 514398 | | Wooden peg, red top |
| **Delta cliff** | D1 | 8264000 | 511619 | | Green metal pegs |
| | D2 | 8264015 | 511524 | 24 | Green metal pegs |
| | D3 | 8263865 | 511372 | | Green metal pegs |
| | D4 | 8263764 | 511379 | | Green metal pegs |
| **Soil micromet station** | M4 (Zac Ra | 8264868 | 513382 | 45 | Black painted double tripod |
| **Soil water** | Dry-2 | 8265563 | 513365 | | Waterproof box |
| | Dry-1 | 8265045 | 513816 | 40 | Waterproof box |
| | Sal-2 | 8264692 | 513623 | 32 | Waterproof box |
| | Sal-1 | 8264649 | 513045 | 35 | Waterproof box |

| Monitoring site | ID | Northing, mN | Easting, mE | Elev. m a.s.l. | Marking |
|---|---|---|---|---|---|
| | Mix1 | 8264348 | 513567 | 33 | Waterproof box |
| | K2 | 8264760 | 513365 | 45 | Teflon lines |
| | K3 | 8264753 | 513349 | 45 | Teflon lines |
| | S2 | 8263950 | 513016 | 10 | Teflon lines |
| | S3 | 8263950 | 513016 | 10 | Teflon lines |
| | | | | | |
| **TinyTag** | P1 | 8263454 | 512323 | 20 | Stone cairn |
| | P2 | 8264257 | 512713 | 23 | Cancelled |
| | P3 | 8268224 | 515917 | 400 | Stone cairn |
| | P4 | 8269597 | 516936 | 820 | Stone cairn |
| | P5 | 8267457 | 509964 | 259 | Stone cairn |
| | P6 | 8263921 | 513068 | 11 | Cancelled |
| | P6-new | | | 11 | Waterproof box |
| | S1 | | | | |
| | Plateau abo | 8264605 | 512168 | 29 | Stone cairn |
| | Slope high | 8264593 | 512171 | 25 | Stone cairn |
| | Slope low | 8264588 | 512171 | 23 | Stone cairn |
| | Plateau bel | 8264493 | 512195 | 16 | Stone cairn |
| | T1 | 8268397 | 511090 | 85 | Stone cairn |
| | T2 | 8269215 | 509105 | 129 | Stone cairn |
| | T3 | 8269902 | 518023 | 965 | Stone cairn |
| | V1 | 8264548 | 512654 | 14 | Cancelled |
| | V2 | 8264538 | 512978 | 35 | Stone cairn |
| **Nansenblokken** | T4 | 8265315 | 510992 | 477 | Stone cairn |
| **Domebjerget** | T5 | 8273009 | 507408 | 1278 | Box on the Repeater station |
| | | | | | |
| **Micrometeorological station** | M1 | 8264893 | 513415 | 40 | |
| Mast | | 8264887 | 513420 | 40 | |
| Solar panel | | 8264888 | 513403 | 40 | |
| Strålingsopst | | 8264888 | 513378 | 40 | |
| | | | | | |
| **Climate station** | C | 8264700 | 513400 | 38 | |
| Snow mast | st 644 | 8264774 | 513380 | 38 | |
| Open precipitation gauge | | 8264751 | 513388 | 38 | |
| TDR station | | 8264747 | 513377 | 38 | |
| East | st 640 | 8264743 | 513382 | 38 | |
| West | st 641 | 8264738 | 513389 | 38 | |
| | | | | | |
| **Hydrometric station** | st 642 | 8264588 | 512606 | 14 | |
| Big rock western bank | | 8264601 | 512627 | 14 | |
| Barrels, eastern bank | | 8264597 | 512613 | 14 | |
| Stage level | | 8264586 | 512622 | 14 | |
| | | | | | |
| **Store Sødal station** | St 645 | 8269851 | 504500 | | |
| | | | | | |
| **Snow and micromet stations** | M2 | 8264501 | 512748 | 17 | |
| | M3 | 8269870 | 517503 | 420 | |
| | | | | | |
| Snow depth, Hydrometric station | St 0 | 8264596 | 512605 | 14 | |
| Snow depth, M2 | St 1 | 8264501 | 512748 | 17 | |
| Stake 2 | St 2 | 8263902 | 513648 | | Iron rod |
| Stake 3 | St 3 | 8264686 | 513471 | | Iron rod |
| Snow depth, Climate station | St 4 | 8264774 | 513380 | 38 | |
| Stake 5 | St 5 | 8266089 | 513538 | | Iron rod |
| Stake 6 | St 6 | 8267092 | 513641 | | Iron rod |
| Snow depth, M3 | St 7 | 8269870 | 517503 | 420 | |

| Monitoring site | ID | Northing, mN | Easting, mE | Elev. m a.s.l. | Marking |
|---|---|---|---|---|---|
| **Tributaries** | | | | | |
| St.Sødal | RS1 | 8268706 | 511750 | | |
| Lindeman | RS2 | 8268914 | 511756 | | |
| Palnatoke NW | RS3 | 8269019 | 511848 | | |
| Palnatoke S | RS4 | 8268599 | 512345 | | |
| Aucella S | RS5 | 8266854 | 512460 | | |
| Aucella N | RS6 | 8268002 | 512400 | | |
| Rylekær | RS7 | 8265629 | 513184 | | |
| Tørvekær | RS8 | | | | |
| | | | | | |
| **ZEROCALM-1** | 1NW | 8264856 | 513363 | 39 | Road marker |
| | 1NE | 8264847 | 513461 | 39 | Road marker |
| | 1SE | 8264748 | 513446 | 38 | Road marker |
| | 1SW | 8264758 | 513347 | 38 | Road marker |
| | | | | | |
| **ZEROCALM-2** | 2NW | 8264083 | 513025 | 19 | Road marker |
| | 2NE | 8264033 | 513167 | 19 | Road marker |
| | 2SE | 8263920 | 513127 | 11 | Road marker |
| | 2SW | 8263970 | 512985 | 9 | Road marker |
| | | | | | |
| **Divere** | | | | | |
| Lindeman | Di1 | 8269102 | 511663 | 86 | |
| Store Sødal, StreamS | Di2 | 8270246 | 497657 | 160 | |
| Store Sødal, StreamN | Di3 | 8271007 | 497546 | 178 | |
| Barodiver, Hydro | Ba1 | | | 14 | |
| Barodiver, Lindeman | Ba2 | 8269102 | 511663 | 89 | |
| Lerbugt | Di4 | 8257274 | 501211 | 18 | |
| | | | | | |
| **Ice vedge growth** | IW1 | 8264359 | 512670 | | Yellow pegs |
| | IW2 | 8264109 | 512624 | | Yellow pegs |
| | IW3 | 8263464 | 512310 | | Yellow pegs |
| | | Ude ved Ulvehøj | | | |
| | | | | | |
| **Salt marsh accretion** | SM | 8263363 | 512415 | | Iron peg |
| | | | | | |
| **Sulifluction lobes** | SL1 | 8264053 | 512365 | | Yellow pegs |
| | SL2 | 8264065 | 512341 | | Yellow pegs |
| | SL3 | 8263885 | 512571 | | Yellow pegs |
| | | | | | |
| **Talus slopes** | TS | | | | |
| | | | | | |
| **Wind abrasion** | WA | 8268397 | 511090 | | Stones |
| | | | | | |
| **Fix points** | | | | | |
| | F1 | 8264594 | 512647 | | Red cross on top of big boulder |
| | F2 | 8264601 | 512614 | | Pink circle on top of big boulder |
| | F3 | 8264600 | 512763 | | Peg north of the station |
| | DPC Z001 | 8264535 | 512683 | 34,78 | |
| | DPC Z004 | 8264738 | 513404 | 37,59 | |
| | DPC Z007 | | | 3,8 | |
| | F4 | | | | |
| | | | | | |
| **ZERO-line** | # 155 | 8269901 | 518028 | | Metal peg with plate |
| | # 150 | 8269916 | 517760 | | Metal peg with plate |
| | #145 | 8269902 | 518027 | | Metal peg with plate |
| | #137 | 8269625 | 516917 | | Metal peg with plate |
| | # 107 | 8269219 | 516555 | | Metal peg with plate |

| Monitoring site | ID | Northing, mN | Easting, mE | Elev. m a.s.l. | Marking |
|---|---|---|---|---|---|
| | #103 | 8268517 | 516151 | | Metal peg with plate |
| | # 99 | 8268084 | 515841 | | Metal peg with plate |
| | # 95 | 8267598 | 515464 | | Metal peg with plate |
| | # 92 | 8267022 | 515017 | | Metal peg with plate |
| | # 91 | 8266903 | 514927 | | Metal peg with plate |
| | # 36 | 8264977 | 513591 | | Metal peg with plate |
| | # 12 | 8264109 | 513037 | | Metal peg with plate |
| | #1 | 8263627 | 512732 | | Metal peg with plate |
| | #11 | 8263980 | 512953 | | Metal peg with plate |
| | #12 | 8264109 | 513037 | | Metal peg with plate |
| | #13 | 8264020 | 512982 | | Metal peg with plate |
| | #2 | 8263655 | 512748 | | Metal peg with plate |
| | #18 | 8264108 | 513038 | | Metal peg with plate |
| | #20 | 8264161 | 513073 | | Metal peg with plate |
| | #3 | 8263772 | 512824 | | Metal peg with plate |
| | #38 | 8265176 | 513714 | | Metal peg with plate |
| | #24 | 8264323 | 513173 | | Metal peg with plate |
| | #26 | 8264372 | 513207 | | Metal peg with plate |
| | #42 | 8265315 | 513804 | | Metal peg with plate |
| | #5 | 8263794 | 512837 | | Metal peg with plate |
| | #9 | 8263860 | 512881 | | Metal peg with plate |

# APPENDIX 5

## DOY (Day of Year)-Calendar

## GEOBASIS

## APPENDIX 5
Day of year (DOY) calendar

### DAY OF YEAR (JULIAN) CALENDAR

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JAN | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| FEB | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | | |
| MAR | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| APR | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 | 111 | 112 | 113 | 114 | 115 | 116 | 117 | 118 | 119 | 120 | |
| MAY | 121 | 122 | 123 | 124 | 125 | 126 | 127 | 128 | 129 | 130 | 131 | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 | 141 | 142 | 143 | 144 | 145 | 146 | 147 | 148 | 149 | 150 | 151 |
| JUN | 152 | 153 | 154 | 155 | 156 | 157 | 158 | 159 | 160 | 161 | 162 | 163 | 164 | 165 | 166 | 167 | 168 | 169 | 170 | 171 | 172 | 173 | 174 | 175 | 176 | 177 | 178 | 179 | 180 | 181 | |
| JUL | 182 | 183 | 184 | 185 | 186 | 187 | 188 | 189 | 190 | 191 | 192 | 193 | 194 | 195 | 196 | 197 | 198 | 199 | 200 | 201 | 202 | 203 | 204 | 205 | 206 | 207 | 208 | 209 | 210 | 211 | 212 |
| AUG | 213 | 214 | 215 | 216 | 217 | 218 | 219 | 220 | 221 | 222 | 223 | 224 | 225 | 226 | 227 | 228 | 229 | 230 | 231 | 232 | 233 | 234 | 235 | 236 | 237 | 238 | 239 | 240 | 241 | 242 | 243 |
| SEP | 244 | 245 | 246 | 247 | 248 | 249 | 250 | 251 | 252 | 253 | 254 | 255 | 256 | 257 | 258 | 259 | 260 | 261 | 262 | 263 | 264 | 265 | 266 | 267 | 268 | 269 | 270 | 271 | 272 | 273 | |
| OCT | 274 | 275 | 276 | 277 | 278 | 279 | 280 | 281 | 282 | 283 | 284 | 285 | 286 | 287 | 288 | 289 | 290 | 291 | 292 | 293 | 294 | 295 | 296 | 297 | 298 | 299 | 300 | 301 | 302 | 303 | 304 |
| NOV | 305 | 306 | 307 | 308 | 309 | 310 | 311 | 312 | 313 | 314 | 315 | 316 | 317 | 318 | 319 | 320 | 321 | 322 | 323 | 324 | 325 | 326 | 327 | 328 | 329 | 330 | 331 | 332 | 333 | 334 | |
| DEC | 335 | 336 | 337 | 338 | 339 | 340 | 341 | 342 | 343 | 344 | 345 | 346 | 347 | 348 | 349 | 350 | 351 | 352 | 353 | 354 | 355 | 356 | 357 | 358 | 359 | 360 | 361 | 362 | 363 | 364 | 365 |

Add 1 to unshaded values during leap years.