Snow survey

Joint field trip in the courses GEO2330 and GEO2210, spring 2022
27 February 2023, ca. 9:00 – 13:00, at Voksenkollen

Overview

The purpose of this lab is to examine the properties and variability of snow cover by measuring snow depth, snow density and stratigraphy. A report is mandatory for both classes.

Procedure for snow measurements

Each group chooses a transect for **multiple snow depth measurements**; ideally groups choose different landscape characteristics (such as open field or forest). A **snow pit** will be dug at one location along the transect to measure **snow temperatures** and **snow stratigraphy**. To keep the snow undisturbed, make sure you walk on one side of the transect and take measurements on the other side. The snow should also be undisturbed on the side of the snow pit where the measurements will be taken.

1. **Snow depth measurements**
   - Extend a measuring tape 30 meters along a transect, and measure the snow depth at each meter mark using a snow probe, i.e. a total of 31 snow depth measurements. Record the snow depth (with 1 cm accuracy) and the distance along the transect.
2. **Snow temperature measurements in the snow pit**
   - Find a suitable spot along your transect and dig a **snow pit** all the way down to the ground. One pit wall (should not be sun-lit) should be undisturbed and vertical for the measurements.
3. **Snow temperature measurements**
   - Measure the snow temperature along the profile by inserting the **thermometer** horizontally into the snow. Record the temperature close to the top, the bottom of the snow pack, and at sufficient intervals in between to capture the profile well.
   - Before you measure hypothesize what you expect. How do you think the vertical temperature profile looks like?
4. **Snow density measurements**
   - Insert the **snow tube** vertically from the top, until it is filled or reaches the ground. Insert first the spatula horizontally where you expect the bottom of the tube to hit to avoid that the tube accidentally slips deeper than it should.
   - Extract the snow tube using the spatula and transfer the snow into the plastic bag without losing (or adding) any snow, and **weigh the snow** with the spring scale.
   - Remember to measure the diameter and length of the snow tube, and the height of the last sample since the remaining snow may be less deep than the length of the tube. Be consistent on where you set your 0 point (top or bottom).
5. **Snow stratigraphy**

   Record the stratigraphy:
   a) **ice lenses, distinct layers** (e.g. depth hoar) or any other remarkable observations
   b) Record the **hardness** of the snowpack using the hand hardness scale. Start with moving your finger vertically from top to bottom along the pit wall and feel and hardness differences and identify different layers. Mark them with the small wood sticks. Then determine the hardness of each layer as defined by the biggest object that is able to penetrate the snow.
   - Take your fist and press it gently against your layer. If it can penetrate into the snow you have a very **soft** layer. Note **F** for fist as the hardness of your layer.
   - If you can't penetrate with your fist, use four fingers and press with the same force as with the fist against the layer. If they go into the snow, note **4F** for four fingers.
   - If that doesn't work, take one finger next. If you penetrate, note **1F** for one finger. That is **medium** hardness.
   - The next step is to try to penetrate into the snow with the tip of a pencil. If it goes in, you note **P** for pencil or a hard layer.
   - Lastly, you can take the tip of a knife. If it penetrates you note **K** for knife, a very hard layer.
   - Layers that can't be penetrated by a knife either, are classified as ice (**I**).

Table 2.1 Hand Hardness Index

Symbol	Hand Test	Term	Graphic Symbol
F	Fist in glove	Very low	
4F	Four fingers in glove	Low	
1F	One finger in glove	Medium	
P	Sharp end of pencil	High	
K	Knife blade	Very high	
I	Too hard to insert knife	Ice	

Source: https://culter.colorado.edu/~kittel/WEcol_Handouts/SnowPit_Protocol&Guide.pdf

c) Estimate the **grain size** for the different layers identified in b) using the plastic crystal card in your snow pit kit.

d) Have a look at individual **snow crystals**. Do they appear fresh or have the shapes been rounded and broken?

Report

Choose one student from each group to be responsible for uploading the collected data to Canvas as an Excel file. Results should be summarized in a short report. This report is obligatory and counts 30 % towards the final grade in GEO2330. For GEO2210 students, the report must be approved (pass/fail) For both courses it must be submitted latest two weeks after the excursion. All reports submitted to Inspera will be checked for plagiarism, so make sure you cite and reference text correctly. If you are in doubt, ask your instructor before submitting.

Photos taken in the field may be useful additions to your report. Your report should contain the following elements (including **figures** and **photos** where appropriate):

1) **Introduction**
   Provide some introduction on the purpose and background theory of the snow survey.

2) **Study area**
   Briefly describe the study area (give approximate latitude/longitude coordinates). Include the position of your transects, either as coordinates, map, and any pictures taken in the field or sketches. Also add the information about the weather condition) and information about the location of your snow pit (aspect, location description).

3) **Methods**
   Describe briefly the equipment and methods used for the snow survey. Include the length and diameter of the snow tube you used. Pictures taken in the field may be useful.

4) **Results**
   Include the following data analyses (the exact tasks may vary depending on the snow conditions):

   Snow depth: For each transect, estimate the average snow depth x, the standard deviation s_x and coefficient of variation ($C_v = s_x/x$).

   Snow density:

   - For each sample compute the **density = mass/volume**. Compute **volume** from your measurements of the sampling device and express the density in kg/m³. Note 1000 kg/m³ = 1 g/L.

     Compute the **snow water equivalent** SWE, which provides a measure of how much water the snowpack contains. SWE (in m w.e.) is computed by integrating the snow density ρ_{snow} [kg/m³] over the depth of the snowpack [m] and dividing by the density of water ρ_{water} [kg/m³].

$$SWE = \frac{1}{\rho_{water}} \int_{h=0}^{H} \rho_{snow}\, dh = \frac{\rho_{snow\_mean}}{\rho_{water}} H. \quad \text{(Equation 1)}$$

     ρ_{mean} is the mean density of the entire snowpack and H is the total snow depth. *SWE* is equivalent to the depth of the snowpack if it was entirely melted. SWE can also be expressed in kg/m² , i.e. Equation 1 without dividing by the density of water. (1000 kg/m² is equivalent to 1 m w.e.). Mass [kg] refers to snow mass.

- Compute the **mean snow density** and total **snow water equivalent** (m w.e.) of the entire snow column (make sure to account for an only partially filled snow tube which typically occurs for the lowest sample. *Note that the mean density is not the mean of your sample´s densities if the last sample´s length had a different length than the previous ones. You need to compute the length-weighted mean.*
- Plot the **density as a function of snow depth** (x-axis=density, y-axis=depth below the surface (negative numbers) (only if the snow is sufficiently deep to have several vertical samples).

Snow temperature and stratigraphy:

- Plot the **temperature as a function of snow depth** (x-axis=snow temperature, y-axis=depth below the surface (negative numbers) (only if the snow is sufficiently deep to have several vertical samples). What is th e physically plausible temperature range for snow? Make sure you correct the readings if needed. Report your raw data and if needed corrected data, and justify your correction. Add the information about stratigraphy in the plot as well (layering, hardness, grain size).

5) Discussion

- Explain the snow density, temperature and stratigraphy profiles. What explains the differences in theses variables with depth?
- How would the temperature profile change immediately after a very cold night? Add such a theoretical profile to your temperature plot. Explain your choice.
- If you were a burrowing animal, where would the most comfortable place in the snowpack be, and why? This answer would explain where most non-hibernating rodents, like squirrels, voles, and mice, live during the winters.

6) Conclusions

Summarize your main conclusions of the observations and your analyses in a few sentences.

List of equipment

- Bring calculator, paper, pen
- For the transect (will be provided): Measuring band and snow probes. For the snow pit (will be provided): Shovel, snow pit kit including snow tube, spatula, scale to weigh snow, bag for snow samples, thermometer

Snowpack stability test

https://www.youtube.com/watch?v=OvwhuP4qtQg

Figure 1. Snow measurements.
1) A measuring band defines the transect and a snow stake is inserted into the snow at regular intervals,
2) Snow is extracted from a snow pit using a snow tube and spatula,
3) The snow is weighed (record the height of snow inside the tube first),
4) The snow temperature is recorded at several depths

Data sheet for recording observations

Weather Conditions: _____ Air Temperature: _____

Characteristics of snow pit location (location, aspect, forested? …) _____

Height of Sampler:_____ Diameter of Sampler: _____ Type of sampler: tube or wedge

Mass of sample bag: _____

Density measurements

SAMPLE #	Depth of base of sampler (cm)	Cumulative depth below the surface	Length of vertical sample	Mass <u>including</u> mass of bag	Mass <u>excluding</u> mass of bag	Snow density (kg/m^3)	Water equivalent (m w.e.)	REMARKS

Snow temperature

Depth from top	Temperature (°C)

Snow stratigraphy

Depth from top (cm)	**Stratigraphy**: ice layers or any other notable observations, grain size etc including the exact depth or depth range.