Tryvann Field Report

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Repository: https://github.com/LisaJN/GEO2210/tree/main/Tryvann
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Abstract—In this report we examine the properties and variability of the snow cover by measuring the depth, density and stratigraphy of a snow pack in Tryvann. We compared all our results with data taken from a slightly different point in the same area, and found that although there were some variability in our results, they are similar enough for us to make some general conclusions about the properties of snow. Our main findings were that the temperature in the snowpack can be divided into three sections; top, middle and bottom, where the top layer is dependent on diurnal variations, the middle layer is often coldest and icy due to melting, and the bottom layer is warm due to heating from the ground, making it the most comfortable for burrowing animals. The density, stratigraphy and SWE are closely connected as ice is denser than snow and the density increased with depth and changes in the stratigraphy.

I. Introduction

The goal of this project is to examine the properties and variability of snow cover by measuring the depth, density and stratigraphy. We want to compare our data with one other group to see if the specific area we collected the data would have a great affect on the results. The data from the two groups, henceforth known as original (our data) and comparison(the borrowed data), are presented in the results chapter. The data was collected at Tryvann on the 27th of February 2023 between 9:00-13:00 in the morning. The data sets, additional photos and figures can be found **here**, or by copying the link to the repository above.
We have a few questions to be answered as well, with the first one being why and how these variables mentioned, vary with depth. How would the temperature profile change given different conditions and where in the snow pack would a burrowing animal be the most comfortable?
We also connect the density with the snow water equivalents(SWE).

II. Study area

The coordinates to our 30m transect:

59.983152, 10.665676
59.983275, 10.665311

M.A.S.L: 504

The weather that day was very good, it was sunny, with little to no wind, clear skies and approximately 1°C in the air. The weather during the week before our trip however, had been somewhat turbulent as it had first rained, then snowed and then, two days before our trip, been very sunny and warm.

Fig. 1: The area we chose to measure the transect. Photo taken from the exact position of the snow pit.

The snow pit originally measured: 83cm with the snow probe, but the actual depth ended up being 62cm.

III. Method

Instruments

- Spatula
- Measuring tape
- Snow probe
- Scale
- Thermometer
- Plastic bag, w:2.5g

- Pen + paper
- Shovel
- Snow tube, l:19cm, d:6cm
- Crystal card
- Rubber mallet

Measurements

1. Transect & snow pit

We chose a somewhat clear area (fig.1) and used the snow probe to test the depth and chose a place to start digging our snow pit. The profile we were measuring had to be away from the sun, and the snow behind needed to be as undisturbed as possible whilst we were executing the measurements. Then we walked 30m with a measuring tape and used the snow probe to measure depth for each 1m of the transect.

2. Temperature

Before conducting the temperature measurements we made a hypothesis of the profile in the snow pack. We thought that it would be coldest in the middle, and warmer at the top, and bottom (warmer closer to the ground than the top).
We inserted the thermometer at the bottom of the snow pack and then measured with a 5cm interval to the top.

3. Density

For the density measurements we used the snow tube and inserted it vertically from the top down the snow pack until it was completely full. Then we used the spatula to lift it out and into the bag attached to the scale.

4. Stratigraphy

From the previous measurements we had divided the snow pack into clear layers and so we chose to take samples from each of these layers. We used the crystal card to measure the snow crystals from each layer in the snow pack. Each square on the card is $2mm^2$.

5. Equations

These are the equations used to present the plots in the result section, the calculations are available in the excel sheets in the repository. The volume is the volume of the snow tube, and we multiply by 1000 to get the answers in kg/m^3

$$Density = \frac{Mass}{Volume} * 1000 \tag{1}$$

$$SWE = \frac{1}{\rho_{water}} \int_{h=0}^{H} \rho_{snow} dh = \frac{\rho_{snowmean}}{\rho_{water}} H \tag{2}$$

IV. Results

For all of the figures the full line is the data we collected and the dashed line is the data from the other group that we are comparing with. The CSV files and Python scripts are available to download from the GitHub **repository**. Some of the graphs are in separate plots due to the difference in depth of the snow pack and amount of measurements. The plots in the snow pit section are reversed meaning 0 is actually the top layer.

Transect

Below is both transects plotted together. They both vary a lot, not just separately, but also when compared.

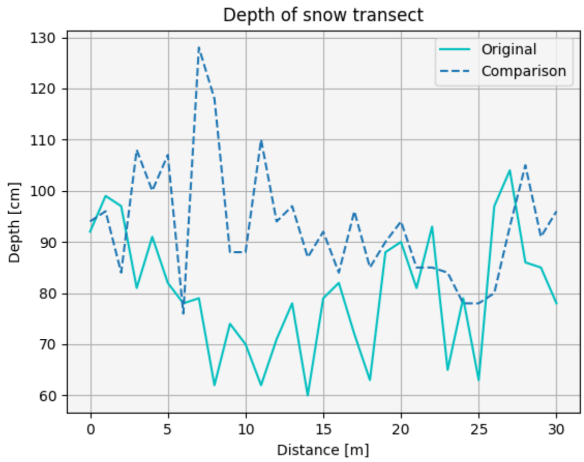

Fig. 2: The difference in depth along our transect compared to another group.

Snow pit

Below is the plot of the change in temperature for both snow packs.

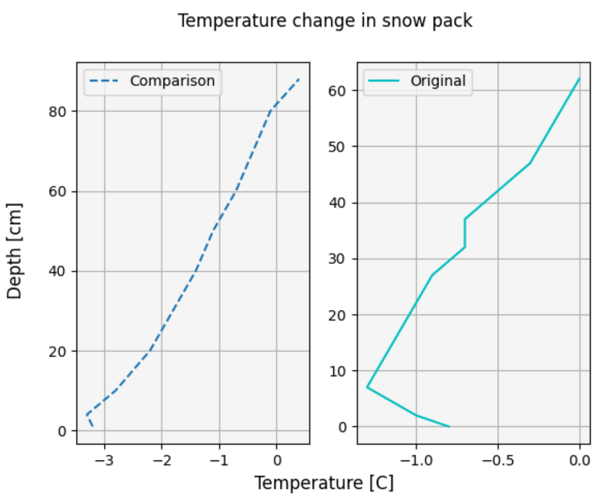

Fig. 3: The difference in temperature in our snow pack compared to another group.

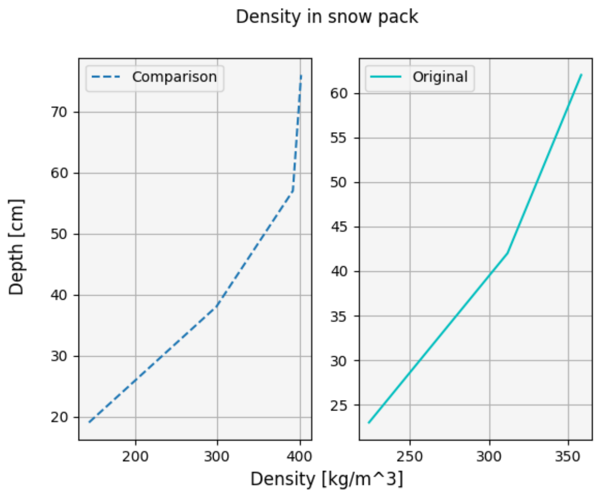

Fig. 4: The difference in density in our snow pack compared to another group.

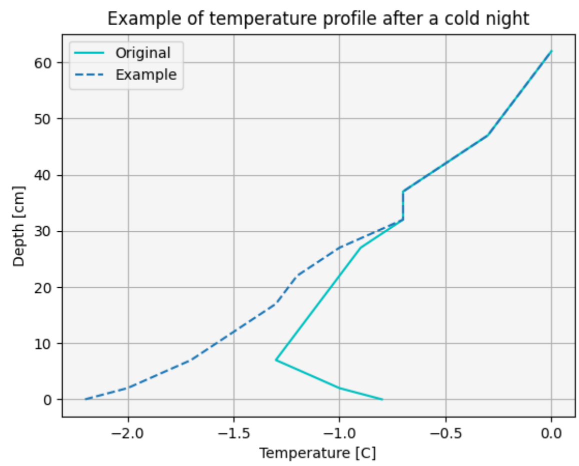

Fig. 6: The temperature profile after a cold night plotted with the original temperature profile for comparison.

TABLE 1: IN THE TABLE BELOW IS AN OVERVIEW OF THE MEAN DENSITY $MD_o(original)$, $MD_c(comparison)$ IN $[kg/m^3]$, THE SNOW WATER EQUIVALENTS $SWE_o(original)$, $SWE_c(comparison)$ IN $[m]$ AND THE AVERAGE SNOW DEPTH $x_o(original)$ AND $x_c(comparison)$ IN $[cm]$.

MD_O	MD_c	SWE_o	SWE_c	x_O	x_c
223.6	309.4	0.183	0.235	80.1	93.3

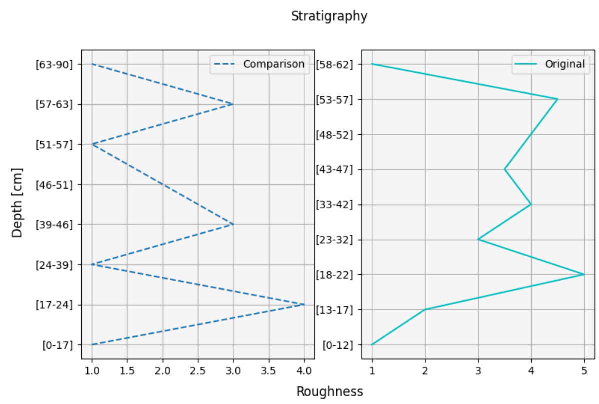

Fig. 7: Stratigraphy in our the snow pit plotted with another group for comparison.

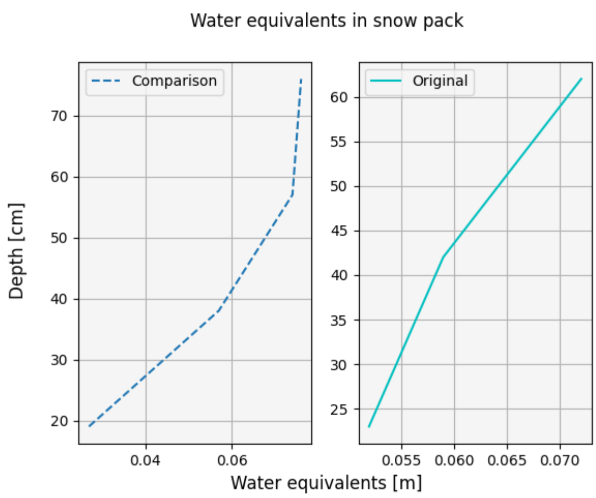

Fig. 5: The difference in MWE in our snow pack compared to another group.

V. DISCUSSION

Firstly, looking at the difference in our transects (fig.2) we can say something about the impact of the area of where the samples were taken. The group we compared our data with did all their measurements in a less forested area. The original measurements are not as deep as the comparisons with an approximately 13cm difference in average depth (table 1). This might be due to the trees covering the ground, making the overall amount of snow in the area lower. There are great variations in both measurements, which makes sense since this was a very varied terrain. Furthermore, our snow pit was not at the deepest point of the transect. Normally we would have measured a transect before choosing where to dig the snow pit, however as er did not have access to a measuring tape until later, we had to just pick a seemingly good spot and start digging. We, of course, saw later that we ended up with one of the shallower areas of the transect which is not necessarily ideal. In addition to this, the point we choose was not as deep as we had first assumed. This is most likely due to the snow probe plunging straight through the soft grass underneath.

When looking at the temperature profile (fig.3) we can see that the hypothesis we made beforehand was correct. The reason why we assumed it would be warmer closer to the ground was due to heating from the ground up in the snowpack (we do not have permafrost here). We also assumed the top layer would be warmer and then the coldest in the middle. This is because the top layer (around 30cm) is more sensitive to temperature changes in the air. Since the temperature in the air was 1°C and our snow pit was in a sunny spot we correctly assumed the very top layer would be warmer. However, snow is not a very good conductor, and works more like an insulator. Therefore, the heat from the top layer, which only started warming as the sun started rising, would not reach the middle of the pack very fast. And if we look at the stratigraphy (fig.7) we can see that there is an ice layer in the middle which also would lead to cooling. This could possibly be related to rain or melting from the previous week but could be older than that as well. The comparison plot is more linear and is probably due to the snow pit being away from the sun.

We did plot one example of what the temperature plot would look like after a very cold night (fig. 6). Here we see that the top layer would be colder, but that the rest of the snowpack would remain the same as the snow insulates (especially due to the ice layer), and would not be affected by the diurnal fluctuations.

The density plots (fig.4) are both very similar, the further down in the snowpack we go, the denser it becomes. This is closely connected with the SWE (fig.5). We already know that ice is denser than snow and we can see this reflected in the figures as the layers further down are more tightly packed in comparison to the more porous top layers. Following the SWE (fig. 5) it makes sense that the bottom layers contain more water than the top layers seeing as they are clearly denser and have more icy layers (fig.7). This is due to melting form the top layer and the water making its way down the pack and re-freezing as the temperature drops, creating layers of ice. We can see a very clear connection when looking at table 1. Here we can see that our transect is generally shallower, less dense and therefore has a lower SWE than the comparison.

Where in the snowpack is the most comfortable? From our temperature measurements and our analysis of said data, we can say with some certainty that the bottom of the pack is where the burrowing animals would be. For a quick recap, the middle layer is the coldest and the top layer is dependent on the weather conditions, making it very varied and possibly colder than the middle. The bottom layer however is more stable and warmer as the ground heats the layer from below since we do not have permafrost here.

VI. Conclusion

In conclusion we can say that there is a very close connection between the depth, density, stratigraphy, snow water equivalents and temperature. The top layer of the snow cover is very sensitive to diurnal temperature variations, but snow is insulating and ice is denser than snow, meaning only the top layer will be affected by these changes. The bottom layer is the warmest (depending on weather/surface temperatures) due to warming from the ground.

From this we concluded that this would be the most comfortable for a burrowing animal.

We noted that an increase in density is parallel to an increase in SWE, and that both of these increase with more icy layers and depth. This is due to melting form the top layer and the water making its way down the pack and re-freezing as the temperature drops, creating layers of ice. All of the original data collected correlated very well with the comparison data even with up to 13cm difference in the mean depth and amount of vegetation.