"Glaciology Field Course at Tarfala Research Station, Northern Sweden"
Glaciology EuroLab2
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Temperature and density profiles from two snow pits along snow line north of Tarfala Research Station.

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Introduction

The field course, The GlacioEuroLab2, which this report is based on, was held at Tarfala Research Station from 1st to 8th of April 2001. During the course we was introduced to safety at glaciers, avalanche risk, density and temperature in snow , drilling with PICO-drill, theory and use of radar to measure snow depth, and we also looked at ice crystals from a glacier and a core from the lake.

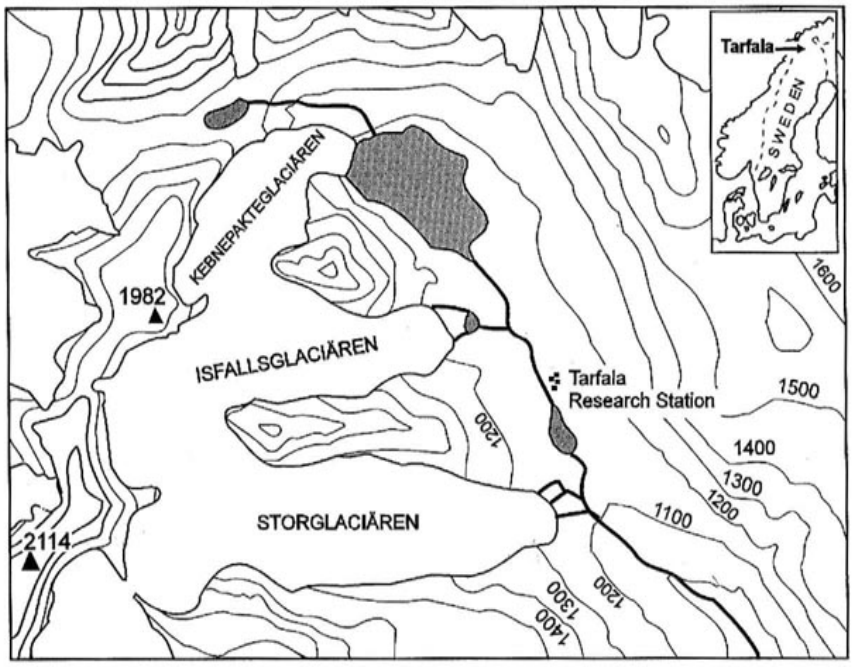


Fig. 1 *Overview Storglasiären and Tarfala area*

From Monday to Friday the weather was not at it's best. Cloudy, snow and low visibility and it was getting worse. It ended Friday night with hard wind and snow. We didn't really believe our eyes the next morning; when we wake up to sun from blue sky.
The snowmobile had problems getting up at Storglaciären and sometimes it was better to be down at the valley for safety reason, and it was also possible to test the equipment there. Wednesday we dug three snow pits along the snow line north of Tarfala. The first pit was near the little hut, the second one about 50m further up, and the last one 50-100m even further north. We were supposed to use the radar measurement along the snow line, but because of bad markers, it was hard to find which marks were the pits. GPS and probing was also failing, so at Saturday, in nice sunny weather and too much new snow (about half a meter or so) for the snowmobile to get up to the glacier, we dug out two new pits near the first and second one to see what the weather had done to the snow pack.

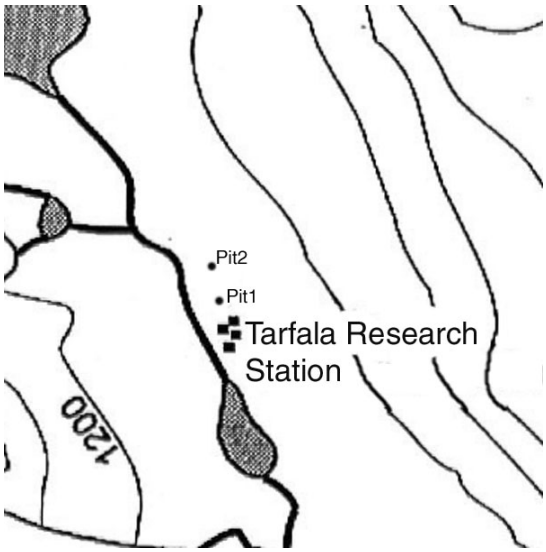


Fig. 2 Left. *Location of the two pits, north of Tarfala Research Station.*

Fig. 3. Left. *Snow pit1 near the little hut. The workers are Ele and Marcel*

Fig. 4. *Right. The people at the right is where pit2 is located*

Method

We tried to take the measurements from a clean wall (no snow from the pit at the top). To compare the pits we tried to dig the new pit as near the other as possible. The second time at pit2 we wanted to take the measurements in the shadow, and since we didn't thought of that when we dug, the snow was a little bit disturb, but by making the pit bigger we tried to avoid that problem.

To measure the temperature profile we used a digital temperature stick. For every 10th cm from top to bottom the temperature stick was in the snow for about half a minute to stabilise the temperature. We also measure the air temperature.

Fig. 5. Left. *Gro is measuring the temperature at pit2*

Fig. 6. Right. *Measurements of the snows mass, done by Marcel*

To measure the density we have to know the mass and the volume. We used cylinders with fixed volume, so we had only to measure the mass of the snow minus the mass of the cylinder. We were using two types of cylinder, one small (1/2 litre) and one big (1 litre). The big one was only used at pit1 the first time. The mass was measured with a digital balance as Marcel show at fig. 6.

The measurements were plotted into Excel to calculate and to be compared. The data was also supposed to be compared with the radar profile along the snow line, but it failed for several reasons.

Fieldwork and results

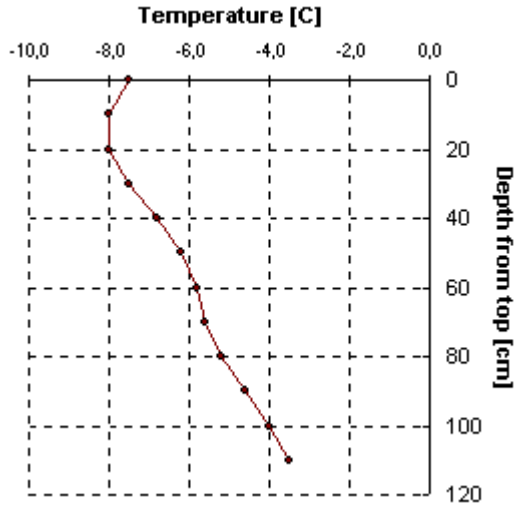
Snow pit1 – just outside the small hut

First: Wednesday 4th (Jim, Pete)

Air temp:

Weather: Cloudy, some snow

Big cylinder

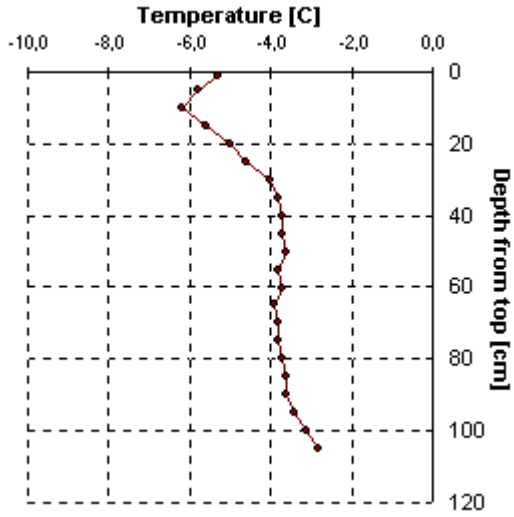


Second: Saturday 7th (Ele, Marcel)

Air temp: -6°C

Weather: Sun from blue sky

Small cylinder



The temperature profile

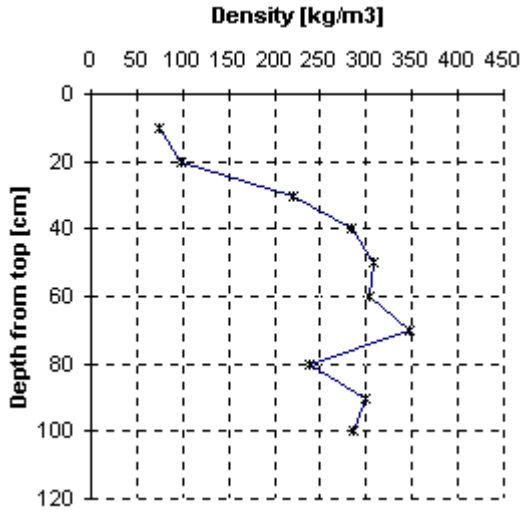
The first pit starts at the top with a temperature around –7,5°C and fall down to min –8,0°C 10-20cm down the snow. From there it start to increase to max. temperature at the bottom (-3,5°C).

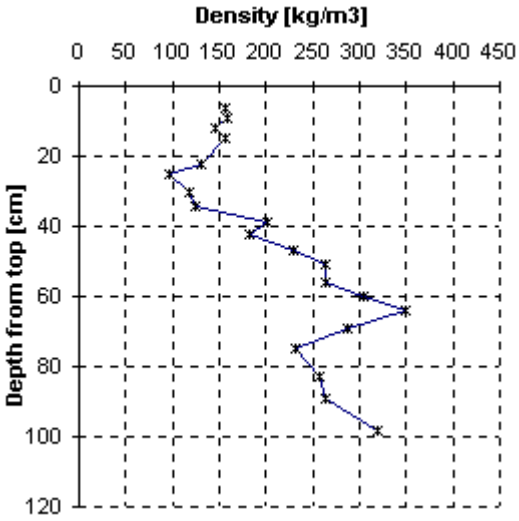
The second pit shows another type of profile. It's steeper at the beginning, probably because of the sunny weather. And it's increasing down to about 30cm were it almost is stabilised and it is decreasing a bit before it is increasing again at about 90 cm. It's reaching it maximum at the bottom, as the first time.

The density profile.

The snow starts at a minimum, only 75 kg/m^3. Is the increasing with a minimum at 70cm were it is decreasing very sharp down at 80 cm were it is increasing again.

The second time it is denser at the top, and reach the minimum down at 25cm. It is increasing again up down to 65cm where it also here have a sharp fall in density, from max. 350 down to 225 kg/cm3. It is then increasing again down to the bottom.

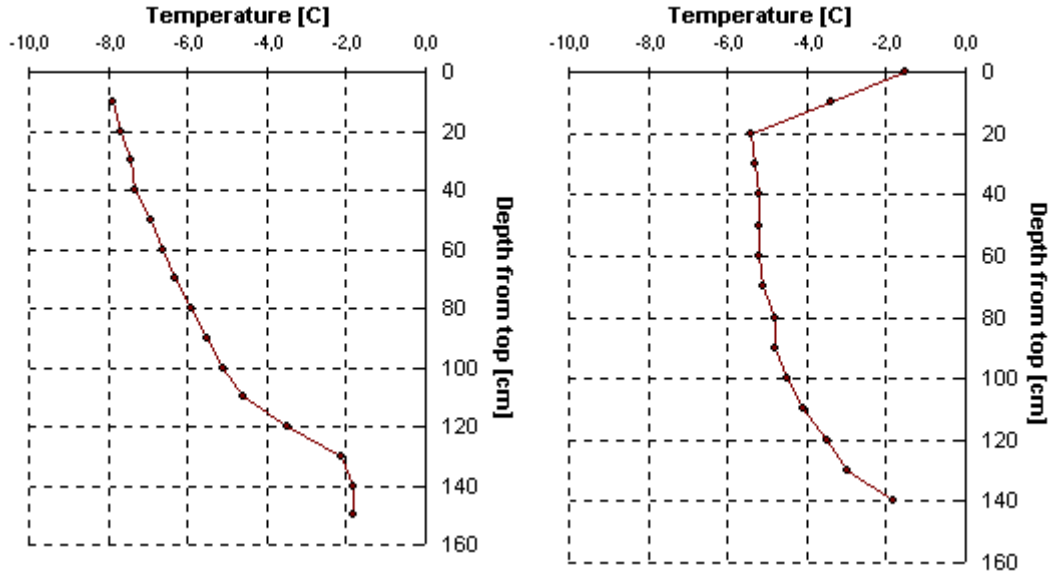




Snow pit 2, about 50m further north

First: Wednesday 4th (Riikka, Greet, Tore)
Air temp: -11,3°C
Weather: Cloudy, some snow
Small cylinder

Second: Saturday 7th (Riikka, Gro, Tore)
Air temp: -5°C
Weather: Sun from blue sky
Small cylinder



Temperature profile

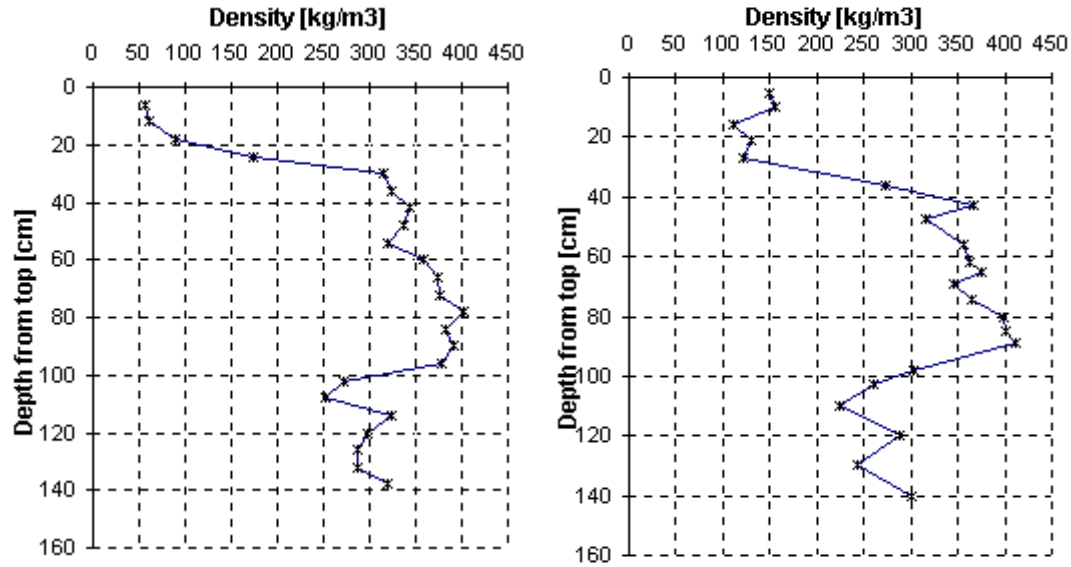
This is also a classic profile, with increasing temperature from –8°C at 10 cm to -2°C near the bottom. Near the bottom the temperature is stabilised around -2°C.

The second time the snow show a warmer profile. At the top it looks strange with a fall from –1,5°C at the top down to min –5,5°C at 20 cm. The temperature is increasing slowly down 90 cm, were it is increasing more steady towards the bottom were it is almost -2°C

Density profile

The density is only start at 50 and is reaching 300 at 30 cm. Down to ca 1m it's almost stabilised around 350 kg/m^3. Then at 1m it is falling down to 225 before it is increasing, then decrease again, before increasing near the bottom.

The second time we got almost the same profile, but it is denser at the top (150) and less dens down at 20-30 cm (100). It is increasing fast up to 350, where it is going a little bit up and down, most up. At 90cm it is falling down from 400 to 200 kg/m3. It is then going up and down, but increase near the bottom.



Discussion and conclusion

The differences we can see from the measurements, are they because of the weather condition the last days, the new location or insecure in measurements?

The temperature profile looks very nice with a increasing temperature towards the ground. The first 20-40cm can show the variation in temperature at daily basis (Johansson, 1999) so the steep gradient the second time is probably because of the radiation of the sun, but its also look like the wind and new snow has heated up the snow pack. The temperature profile looks consistent, so the heating is probably because of the wind and new snow with higher temperature. It looks like the wind has change the temperature down at least 1 meter.

Near the bottom, if the snow is very course, it could be hard not to lose some snow, then the density is to low. But the density profile looks very consistent, with soft snow at the top over a denser layer, and at the bottom a looser layer. It also looks like the wind had made a denser layer near the surface. At pit1, the hole snow pack looks less dens the second time, and is not getting dens as quick as the first time, and that's probably because of the new snow, and the wind the last days. At snow pit2 the denser part at the top could be because of the snow dug out of the pit was doing some pressure, but since we see the same at pit1, it's look like that didn't have so much influence.

Since the snow depth is almost the same both times, the two areas were probably at equilibrium. The sum of new snow accumulation and snow blowing away was almost zero.

It then looks like the wind and new snow coming after the first pits had warmed up the snow pack down to, most at pit1. Most probably because of the wind. The wind has also hardened the top layer, and at pit1 it's also look like the snow pack down to 50 cm is disturbed by the wind. It is probably softer because of the new snow. The sun's effect at the top 10-20cm is also very clear. It is easiest seen at pit2 the second time.
The measurements at the two pits looks very consistent, so if we did anything wrong when we where doing the digging and measurements, it looks like it didn't had so much influence at the results.

Acknowledgements

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References

Johansson, Maria, 1999, "A snow pit study in the surroundings of Tarfala Research Station in Mars 1999", **http://www.urova.fi/home/hkunta/jmoore/mariajohanson.htm**
Wood, Andrew W., 2000, "Distributed Snow Model Validation Exercise. Feb. 16 2000 – Feb. 17, 2000", **http://www.ce.washington.edu/~aww/field/stanley1/stanley1.html**

Appendix 1 data from snow pits

Volume of small cylinder (1/2 litre) [cm3]	480,2866849
Volume of big cylinder (1 litr) [cm3]	990,7797831

Pit1 first time Wednesday 4th April 2001

Airtemp [C]:
Weather: Cloudy, some snow
Big cylinder

Tdepth [cm]	Tsnow [C]	Ddepth [cm]	Mass [g]	Density [kg/m3]
0	-7,5			
10	-8,0	10	74,5	75,2
20	-8,0	20	97,5	98,4
30	-7,5	30	218,5	220,5
40	-6,8	40	281	283,6
50	-6,2	50	305	307,8
60	-5,8	60	301,5	304,3
70	-5,6	70	345	348,2
80	-5,2	80	235	237,2
90	-4,6	90	296	298,8
100	-4,0	100	283	285,6
110	-3,5			

Pit1 second time Saturday 7th April 2001

Airtemp [C]: -6
Weather: Sun from blue sky
Small cylinder

Tdepth [cm]	Tsnow [C]	Ddepth [cm]	Mass [g]	Density [kg/m3]
1	5,3	6	75	156,2
5	5,8	9	76,5	159,3
10	6,2	12	69,5	144,7
15	5,6	15	75,5	157,2
20	5	22	62,5	130,1
25	4,6	25	46	95,8
30	4	30	57	118,7
35	3,8	34	59,5	123,9
40	3,7	39	97	202,0
45	3,7	42	87	181,1
50	3,6	47	110,5	230,1
55	3,8	51	126,5	263,4
60	3,7	56	126,5	263,4
65	3,9	60	146	304,0
70	3,8	64	167,5	348,8
75	3,8	69	138	287,3
80	3,7	75	111,5	232,2
85	3,6	83	123	256,1
90	3,6	89	127	264,4
95	3,4	98	153	318,6
100	3,1			

105 2,8

Pit2 first time Wednesday 4th April

Airtemp [C] -11,3
Weather: Cloudy, some snow
Small cylinder

Tdepth [cm]	Tsnow [C]	Ddepth [cm]	Mass [g]	Density [kg/m3]
1	-11,3	6	27,5	57,3
10	-7,9	12	29	60,4
20	-7,7	18	43	89,5
30	-7,4	24	84	174,9
40	-7,3	30	151	314,4
50	-6,9	36	156	324,8
60	-6,6	42	165	343,5
70	-6,3	48	162	337,3
80	-5,9	54	154	320,6
90	-5,5	60	172	358,1
100	-5,11	66	180	374,8
110	-4,6	72	181	376,9
120	-3,5	78	193	401,8
130	-2,1	84	184	383,1
140	-1,8	90	188	391,4
150	-1,8	96	182	378,9
		102	130	270,7
		108	121	251,9
		114	156	324,8
		120	143	297,7
		126	138	287,3
		132	138	287,3
		138	153	318,6

Pit2 second time Saturday 7th April 2001
Airtemp -5
Weather: Sun from blue sky
Small cylinder

Tdepth [cm]	Tsnow [C]	Ddepth [cm]	Mass [g]	Density [kg/m3]
0	-1,5	5	71,5	148,9
10	-3,4	10	75	156,2
20	-5,4	16	53	110,4
30	-5,3	21	62	129,1
40	-5,2	27	58	120,8
50	-5,2	36	131,5	273,8
60	-5,2	42,5	176	366,4
70	-5,1	47,5	152	316,5
80	-4,8	56	171	356,0
90	-4,8	62	174,5	363,3
100	-4,5	65	180	374,8
110	-4,1	69	166	345,6
120	-3,5	74,5	175,5	365,4
130	-3	80	192	399,8

140	-1,8	85	193	401,8
		89	197,5	411,2
		98	145,5	302,9
		103	125	260,3
		110	107,5	223,8
		120	138	287,3
		130	116,5	242,6
		140	144	299,8