

Biocomplexity of Frost-Boil Ecosystems

Snow Data Report

**Alaska North Slope
April 2004**

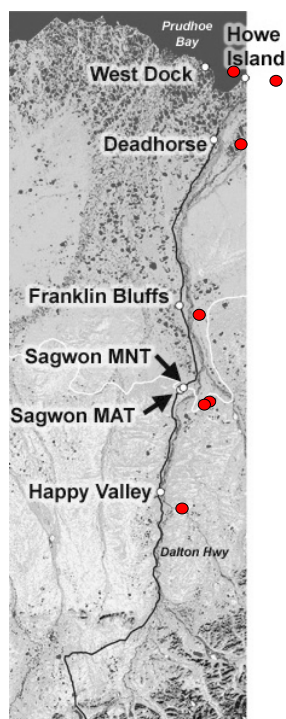
Data Report prepared by M. K. Raynolds, D. A. Walker, C. R. Martin



Alaska Geobotany Center
Institute of Arctic Biology
University of Alaska-Fairbanks
Fairbanks, Alaska 99775

December, 2004

Photo by M. K. Raynolds



Biocomplexity of Frost-Boil Ecosystems

Snow Data Report Alaska North Slope April 2004

TABLE OF CONTENTS

INTRODUCTION.....	1
METHODS	1
RELEVÉ SNOW DEPTH	1
GRID SNOW DEPTHS	1
SNOW DENSITY AND SNOW WATER EQUIVALENT (SWE) AT THE GRIDS	2
HEAVE	2
SNOW PROFILES	2
HAPPY VALLEY 1 X 1 KM GRID AND PERMANENT PLOTS	2
RESULTS	2
LITERATURE CITED	3
ACKNOWLEDGEMENTS	3
TABLES.....	4
TABLE 1. RELEVÉ SNOW DEPTHS , NORTH SLOPE, 13-15 APRIL 2004 (MEASURED BY ANJA KADE).	4
TABLE 2. SNOW DEPTH MEASUREMENTS (CM) ON THE 10 X 10 M BIOCOMPLEXITY GRIDS, APRIL 2004.	7
TABLE 3. DETAILED DEPTH AND DENSITY MEASURED ON THE FOUR SIDES OF THE 10 X 10 M BIOCOMPLEXITY GRIDS, APRIL 2004.	12
TABLE 4. DEPTH, SNOW WATER EQUIVALENT (SWE), AND SNOW DENSITY AT THE BIOCOMPLEXITY GRIDS, APRIL 2004.....	14
TABLE 5. SNOW PROFILES AT BIOCOMPLEXITY GRID SITES, APRIL 2004.	14

TABLE 6. SNOW DEPTHS AT HAPPY VALLEY 1 X 1 KM GRID, APRIL 2004.	17
TABLE 7. SNOW DEPTHS AT HAPPY VALLEY PERMANENT PLOTS, APRIL 2004.	18
FIGURES.....	20
FIGURE 1. MEAN SNOW DEPTH (CM) ON 10 X 10 M GRIDS, NORTH SLOPE, ALASKA, APRIL 2004 (N = 121).	20
FIGURE 2. MEAN SNOW DENSITY (G/CM ³ +/- S.E.) ON 10 X 10 M GRIDS, NORTH SLOPE, ALASKA, APRIL 2004 (N = 4).	20
FIGURE 5. SNOW DEPTHS OF THE 10 X 10 M GRIDS, NORTH SLOPE, ALASKA, APRIL 2004.	21
FIGURE 6. SNOW DEPTHS ON HAPPY VALLEY 1 KM X 1 KM GRID, MAY 2004.....	22
APPENDIX A. PHOTOGRAPHS.....	23
APPENDIX B. DATA COLLECTION FORMS	25
APPENDIX C. CLASSIFICATION OF SNOW CRYSTALS (COLBECK ET AL. 1992).....	28

Biocomplexity of Frost-Boil Ecosystems

Snow Data Report

Alaska North Slope, April 2004

M. K. Raynolds, D. A. Walker, and C. R. Martin

Introduction

This data report is a summary of snow-survey information collected during a trip to the Arctic Slope April 12-15, 2004. The data were all collected as part of the Biocomplexity of Frost-Boil Ecosystems study (Walker et al. 2004). Snow is an important factor affecting soil-surface temperatures during the winter. These data will be used to help model the influence of snow on frost heave.

Members of the survey team included Martha Raynolds, Anja Kade, and Christine Martin, all from the Alaska Geobotany Center and UAF student volunteer Nathan Shoutis. The data collected included

1. Snow depth and soil temperature information from 97 of the 117 permanent plots (relevés) that are part of a vegetation classification study.
2. Snow density and snow-water-equivalent (SWE) measurements from the midpoints of the four sides of each of ten 10x10-m grids at Happy Valley, Sagwon, Franklin Bluffs, and Deadhorse. We were not able to access the grids on B.P.-leased lands at West Dock, and Howe Island, because we did not have B.P.'s "authorization to proceed".
3. Snow depths at every meter within each of the ten grids.
4. Snow profile descriptions from each of the ten grids.
5. Heave measurements from iron re-bar at relevé sites and V. Romanovsky heave meters
6. Snow depth measurements every 100 m within 1 x 1 km plot and at 45 permanent plots at Happy Valley.

Information from this data report and other information from the grids are available on the Alaska Geobotany Center web site: <http://www.geobotany.uaf.edu/cryoturbation/index.html>. Photos from the survey are in Appendix A.

Methods

Relevé snow depth

Snow depth was measured at each relevé at the plot marker using a stainless steel T-bar rod. One measurement was taken at each plot marker.

Grid snow depths

Snow depth was measured at every meter in each grid (Appendix A, Photo 1). If the pin flag marking the grid point location was visible, the measurement was taken immediately adjacent to the pin flag. If the flag was buried by snow, a meter tape was stretched first between A1 and A11 and the snow depth measured at the meter intervals along the tape. The tape was then moved to the next row and the process repeated, until all the rows were completed. Appendix B contains the data sheet used for the grid snow depths. Snow depth maps of the grids were made using the program Transform PPC, version 3.4, by Fortner Software.

Snow density and snow water equivalent (SWE) at the grids

Snow density and water equivalent were measured using a “federal sampler” with a cross section area of 11.464 cm² (Appendix A, Photo 2). One sample was taken at the midpoint of each side of the grids (4 samples per grid). The coring device had a toothed bit, and was inserted first to the soil surface to note the snow depth. It was then cored into the soil to the point where a small sample of soil was included in the core to keep the loose snow from falling out of the corer. The snow was removed from the corer, placed into a plastic bag and weighed (Appendix A, Photo 3). Appendix B contains the data sheets used for the data collection. The federal sampler was borrowed from Matthew Sturm, US Army CRREL, Ft. Wainwright, AK.

Heave

Heave was measured at each of the relevés, and at the heave-meters installed by Vladimir Romanovsky adjacent to the grids (Appendix A, Photos 4, 5).

Snow profiles

Snow trenches were dug at each grid, approximately 3 m long and 2 m wide. Snow surface characteristics were noted (roughness, nature of surface irregularities, depth of irregularities, average wavelength, and compass direction of sastrugi features). The various layers in the snow were described according to thickness of the layer, grain shape (Colbeck et al 1992), grain size (mm), and hardness (fist, 4 fingers, 1 finger, pencil, knife blade; Colbeck et al. 1992). See Appendix B for the snow profile data sheet and Appendix C for classification of snow characteristics.

Happy Valley 1 x 1 km grid and permanent plots

During 22-24 April 2004, snow depths were measured every 100 m within a 1 x 1 km grid at Happy Valley. The large grid includes the dry, moist and wet 10 x 10 m grids. At each site, marked by a 2 m-tall plastic pipe, depth was measured at 4 sites around the stake. Snow depth at three sites could not be measured because seismic vehicle traffic had compacted the snow. Snow depths were also measured at permanent plots which had been subjectively chosen to represent the range of vegetation types occurring in the Happy Valley area. Forty-five of the original 55 permanent plots were located, and five depth measurements were taken at each plot, one at the stake marking the plot and four surrounding it.

Results

Table 1 contains the relevé snow depths. Table 2 (a - j) contains the data and a summary of the mean snow depth, standard deviation, and standard error for each grid. Mean grid snow depths are shown in Figure 1. The deepest snow occurred at the Happy Valley moist and wet grids (mid- and toeslope, 69 and 68 cm, respectively), and the shallowest snow was at the Franklin Bluff dry grid (25 cm). Snow depths generally increased from the coast inland, but as in 2003, deeper snow was encountered at Deadhorse (52 cm). Maps of the snow depths on each grid are shown in Figure 5.

Snow density measurements of each grid are in Table 3 (a-f), and a summary of the average snow depths, snow densities and snow-water equivalents at the grids is in Table 4. The snow density was

greatest at Deadhorse, and least at the Happy Valley wet grid (Figure 2). Snow water equivalent was plotted as a function of snow depth (Figure 3). Snow water equivalent was highest at the Happy Valley moist grid (where average snow depth was greatest), and at Deadhorse (where density was highest) (Figure 4).

Heave results are available from Anja Kade (for relevés) and Vladimir Romanovsky (for heave-meters).

Table 5 (a-e), contains the snow profile descriptions for the five sites samples. The Deadhorse site had depth hoar, which was thicker in the interboil (Appendix A, Photo 6). The difference in the depth hoar compensated for the difference in surface elevation between the frost boil and interboil areas. The surface had a 5-8 cm thick wind-packed slab. This slab resulted in the higher snow density values recorded at Deadhorse (Table 4). The Franklin Bluff site had less dense snow than Deadhorse, but the same pattern of shallower depth hoar on the frost boil was evident (Appendix A, Photo 7). The Happy Valley site had the deepest snow, with a 15 cm layer of metamorphosed crystals above the hoar frost layer (Appendix A, Photo 8).

Table 6 contains the snow depths measured on the 1 km x 1 km Happy Valley grid. The mean snow depth on the grid was 68.0 +/- 1.2 cm. A map of the snow depths is shown in Figure 6. Table 7 lists the snow depths measured at the permanent relevé plots at Happy Valley.

Literature cited

- Colbeck, S, E. Akitaya, R. Armstrong, H. Gubler, J. Lafeuille, K. Lied, D. McClung, E. Morris. 1992. *The International Classification for Seasonal Snow on the Ground*. Issued by the International Commission on Snow and Ice of the International Association of Scientific Hydrology and the International Glaciological Society. Available from STIS, Springfield VA or CRREL, Hanover NH. 37p.
- Walker, D. A., H. E. Epstein, W. A. Gould, J. A. Knudson, W. B. Krantz, R. A. Peterson, C. L. Ping, M. K. Reynolds, V. E. Romanovsky, and Y. Shur. 2004. Frost-boil ecosystems: complex interactions between landforms, soils, vegetation and climate. *Permafrost and Periglacial Processes* 15:171-188.

Acknowledgements

Thanks to Anja Kade and Nathan Shoutis for data collection, and Matthew Sturm and Jon Holmgren for providing the sampling equipment and advice on sampling methods. Thanks to VECO for providing the logistic support. Funds for the data collection and report preparation came from the National Science Foundation grant no. OPP-0120736.

Tables

Table 1. Relevé snow depths , North Slope, 13-15 April 2004 (measured by Anja Kade).

Relevé	Location	Type	Snow depth (cm)	GPS (dd mm ss.s)
106	Deadhorse	bare frost boils	16	70 09 37.0 148 28 07.1
49	Deadhorse	interboil moist	19	70 09 42.6 148 28 00.5
51	Deadhorse	interboil moist	20	70 09 38.2 148 28 08.1
105	Deadhorse	interboil moist	21	70 09 38.2 148 28 09.5
44	Deadhorse	bare frost boils	29	70 09 38.6 148 28 08.6
43	Deadhorse	bare frost boils	32	70 09 41.5 148 27 59.7
50	Deadhorse	interboil moist	38	70 09 38.3 148 28 09.2
41	Deadhorse	vegetated boils	40	70 09 41.9 148 27 59.5
45	Deadhorse	bare frost boils	40	70 09 42.5 148 28 00.0
48	Deadhorse	interboil moist	40	70 09 41.6 148 28 00.0
42	Deadhorse	vegetated boils	42	70 09 38.5 148 28 08.7
39	Deadhorse	vegetated boils	44	70 09 37.2 148 28 10.05
104	Deadhorse	bare frost boils	47	70 09 41.3 148 28 02.5
40	Deadhorse	vegetated boils	52	70 09 41.5 148 27 59.0
38	Deadhorse	vegetated boils	59	70 09 40.8 148 28 00.5
32	Franklin Bluffs	vegetated boil, dry	6	69 40 28.2 148 43 14.0
6	Franklin Bluffs	bare boil, dry	7	69 40 29 148 43 16
31	Franklin Bluffs	bare boil, dry	8	69 40 28.9 148 43 15.7
9	Franklin Bluffs	bare boil, dry	10	69 40 27.4 148 43 13.9
10	Franklin Bluffs	bare boil, dry	10	69 40 26.3 148 43 13.7
33	Franklin Bluffs	bare boil, dry	10	69 40 28.4 148 43 14.5
8	Franklin Bluffs	vegetated boil, dry	11	69 40 27.5 148 43 13.9
5	Franklin Bluffs	vegetated boil, dry	14	69 40 28 148 43 13
35	Franklin Bluffs	interboil dry	14	69 40 28.5 148 43 14.4
97	Franklin Bluffs	vegetated boil, moist	18	69 40 29.3 148 43 18.0
36	Franklin Bluffs	bare boil, wet	19	69 40 25.7 148 43 28.4
118	Franklin Bluffs	bare boil, wet	19	69 40 26.6 148 43 27.4
141	Franklin Bluffs	vegetated boil, moist	19	69 40 28.8 148 43 16.7
30	Franklin Bluffs	vegetated boil, dry	20	69 40 28.9 148 43 15.7
11	Franklin Bluffs	interboil dry	21	69 40 27.4 148 43 13.8
96	Franklin Bluffs	vegetated boil, moist	21	69 40 29.1 148 43 18.4
117	Franklin Bluffs	bare boil, wet	22	69 40 26.1 148 43 29.0
142	Franklin Bluffs	vegetated boil, moist	22	69 40 29.3 148 43 17.8
34	Franklin Bluffs	interboil dry	28	69 40 28.9 148 43 14.8
140	Franklin Bluffs	vegetated boil, moist	29	69 40 28.8 148 43 19.1
7	Franklin Bluffs	vegetated boil, dry	30	69 40 30 148 43 16

Table 1. (continued)

Relevé	Location	Type	Snow depth (cm)	GPS (dd mm ss.s)
3	Franklin Bluffs	bare boil, wet	32	69 40 27.1 148 43 02.4
12	Franklin Bluffs	interboil dry	32	69 40 28 148 43 14
20	Franklin Bluffs	interboil, moist	33	69 40 29.5 148 43 18.2
19	Franklin Bluffs	interboil, moist	34	69 40 29.2 148 43 17.5
2	Franklin Bluffs	bare boil, wet	35	69 40 25.9 148 43 01.8
46	Franklin Bluffs	interboil, moist	36	69 40 28.4 148 43 16.5
1	Franklin Bluffs	bare boil, wet	37	69 40 26.7 148 42 58.4
13	Franklin Bluffs	interboil dry	41	69 40 29 148 43 15
37	Franklin Bluffs	interboil wet	41	69 40 25.9 148 43 28.8
47	Franklin Bluffs	interboil, moist	41	69 40 20.3 148 43 29.8
15	Franklin Bluffs	interboil wet	51	69 40 27.1 148 43 02.4
16	Franklin Bluffs	interboil wet	51	69 40 26.7 148 42 58.4
4	Franklin Bluffs	bare boil, wet	57	69 40 26.3 148 43 07.5
18	Franklin Bluffs	interboil, moist	57	69 40 28.4 148 43 18.2
14	Franklin Bluffs	interboil wet	67	69 40 25.9 148 43 01.8
17	Franklin Bluffs	interboil wet	83	69 40 26.3 148 43 07.5
70	Sagwon MNT	bare boil	32	69 25 56.1 148 40 19.3
63	Sagwon MNT	bare boil	34	69 25 58.8 148 40 23.1
61	Sagwon MNT	vegetatated boil	35	69 25 57.5 148 40 23.2
72	Sagwon MNT	bare boil	37	69 25 58.2 148 40 23.4
64	Sagwon MNT	vegetatated boil	39	69 25 58.3 148 40 23.8
68	Sagwon MNT	interboil moist	39	69 25 59.8 148 40 19.5
60	Sagwon MNT	vegetatated boil	40	69 25 59.3 148 40 21.7
29	Sagwon MNT	interboil moist	41	69 26 00.9 148 40 16.8
69	Sagwon MNT	bare boil	41	69 25 59.1 148 40 22.3
59	Sagwon MNT	vegetatated boil	42	69 25 58.8 148 40 23.8
71	Sagwon MNT	bare boil	44	69 25 56.5 148 40 21.6
55	Sagwon MNT	interboil moist	47	69 25 59.8 148 40 22.0
65	Sagwon MNT	interboil moist	47	69 25 58.5 148 40 23.3
67	Sagwon MNT	interboil moist	48	69 25 54.1 148 40 22.5
58	Sagwon MNT	vegetatated boil	62	69 25 58.7 148 40 23.9
73	Sagwon MAT	vegetated boil (mound)	18	69 25 32.1 148 41 44.3
80	Sagwon MAT	vegetated boil (mound)	20	69 25 33.1 148 41 51.1
78	Sagwon MAT	vegetated boil (mound)	22	69 25 33.2 148 41 43.2
74	Sagwon MAT	vegetated boil (mound)	24	69 25 32.2 148 41 43.2
76	Sagwon MAT	vegetated boil (mound)	29	69 25 32.4 148 41 43.6
62	Sagwon MAT	interboil moist	44	69 25 32.0 148 41 45.3
79	Sagwon MAT	interboil moist	44	69 25 33.0 148 41 44.9

Table 1. (continued)

Relevé	Location	Type	Snow depth (cm)	GPS (dd mm ss.s)
75	Sagwon MAT	interboil moist	45	69 25 32.0 148 41 43.5
77	Sagwon MAT	interboil moist	52	69 25 32.5 148 41 43.6
81	Sagwon MAT	interboil moist	53	69 25 33.2 148 41 51.2
89	Happy Valley	vegetated boil	28	69 08 48.6 148 51 07.1
90	Happy Valley	vegetated boil	28	69 08 48.6 148 51 08.4
57	Happy Valley	bare frost boil, wet	32	69 08 49.1 148 50 49.3
91	Happy Valley	vegetated boil	33	69 08 48.2 148 51 07.8
88	Happy Valley	vegetated boil	43	69 08 48.7 148 51 05.9
92	Happy Valley	vegetated boil	43	69 08 47.6 148 51 08.5
82	Happy Valley	vegetated boil (mound)	55	69 08 48.7 148 50 54.3
94	Happy Valley	vegetated boil (mound)	55	69 08 48.7 148 50 54.0
93	Happy Valley	vegetated boil (mound)	60	69 08 48.9 148 50 53.0
52	Happy Valley	bare frost boil, wet	61	69 08 49.8 148 50 49.1
54	Happy Valley	bare frost boil, wet	63	69 08 48.8 148 50 49.7
56	Happy Valley	bare frost boil, wet	64	69 08 48.7 148 50 48.9
85	Happy Valley	interboil moist	65	69 08 49.4 148 50 52.4
53	Happy Valley	bare frost boil, wet	66	69 08 50.1 148 50 48.7
83	Happy Valley	vegetated boil (mound)	67	69 08 49.9 148 50 53.6
95	Happy Valley	vegetated boil (mound)	70	69 08 50.1 148 50 54.4
84	Happy Valley	interboil moist	71	69 08 49.1 148 50 52.9
87	Happy Valley	interboil moist	73	69 08 49.0 148 50 51.6
66	Happy Valley	interboil moist	77	69 08 48.6 148 50 52.4
86	Happy Valley	interboil moist	77	69 08 49.8 148 50 53.4

Remarks: Relevés on Howe Island and West Dock were not accessible due to BP restrictions. Snow depths were measured next to plot markers.

Table 2. Snow depth measurements (cm) on the 10 x 10 m Biocomplexity Grids, April 2004.

Measurements were made at the pinflags when they were visible or at 1-m intervals along a tape stretched across the grid when the snow depth was deeper than the pin flag height.

a) Location: Howe Island

No data gathered due to oilfield access denied.

b) Location: West Dock

No data gathered due to oilfield access denied.

c) Location: Deadhorse

Photos: Roll 04-01:1 to 9

Date: 15 April 2004

Observers: Martha Raynolds, Nathan Shoutis

Weather: sunny, no wind, 5 °F, ice crystals in air

	1	2	3	4	5	6	7	8	9	10	11
K	49	54	56	58	43	46	38	45	49	50	46
J	59	51	55	50	48	48	50	44	42	50	50
I	56	51	40	46	50	48	51	50	50	50	36
H	52	46	48	47	40	37	50	50	46	50	39
G	37	42	48	45	43	40	51	52	45	47	47
F	45	48	49	50	56	49	46	56	58	65	41
E	56	45	58	60	59	56	57	48	59	62	60
D	53	54	60	53	61	58	61	62	56	61	65
C	58	63	56	53	65	65	64	58	60	55	57
B	61	62	48	60	62	58	59	56	55	51	52
A	54	53	56	50	52	49	57	48	54	48	48

mean = 51.9
SD = 6.8
n = 121.0
SE = 0.6

d) Location: Franklin Bluffs, dry

Observers: Nathan Shoutis, Christine Martin

Date: 14 April 2004

Weather: sunny, windy

	1	2	3	4	5	6	7	8	9	10	11
K	39	29	34	22	32	29	24	31	26	20	25
J	46	32	38	30	38	30	29	31	24	21	22
I	50	31	21	37	34	33	24	14	20	18	12
H	49	37	22	25	35	33	23	11	17	21	19
G	40	41	34	25	33	14	22	29	25	18	20
F	28	33	27	33	34	22	13	26	17	19	26
E	32	33	32	27	33	23	27	26	28	25	18
D	27	20	18	10	20	22	18	14	32	37	13
C	33	26	27	18	25	19	26	19	28	31	20
B	24	18	18	9	22	12	19	23	20	17	13
A	7	17	21	19	19	19	22	30	19	10	10

mean = 24.9
SD = 8.4
n = 121.0
SE = 0.8

Table 2. (continued)

e) Location Franklin Bluffs, moist

Observers: Nathan Shoutis, Christine Martin

Date: 14 April 2004

Weather: sunny, still

	1	2	3	4	5	6	7	8	9	10	11	
K	22	25	33	31	18	41	38	46	33	36	48	
J	24	29	24	39	34	28	39	46	52	52	55	
I	28	28	35	34	32	48	47	50	55	46	39	mean = 39.1
H	40	35	46	28	31	45	48	47	58	38	34	SD = 8.6
G	39	36	28	39	39	34	44	51	36	34	48	n = 121
F	43	39	42	40	37	54	48	50	35	45	43	SE = 0.8
E	37	35	49	38	51	39	37	51	25	42	54	
D	29	33	47	49	34	40	43	44	46	48	40	
C	26	25	19	41	31	39	50	42	33	48	46	
B	31	36	32	41	34	47	33	47	26	35	35	
A	34	40	39	48	43	49	23	33	48	31	41	

f) Location: Franklin Bluffs, wet

Observers: Nathan Shoutis, Christine Martin

Date: 14 April 2004

Weather: sunny, still

	1	2	3	4	5	6	7	8	9	10	11	
K	28	29	25	39	44	44	47	45	40	44	34	
J	29	30	34	39	45	48	49	41	42	47	43	
I	39	38	37	40	48	53	48	44	41	41	44	mean = 43.2
H	42	35	32	33	42	49	49	48	41	42	39	SD = 7.5
G	41	35	32	31	42	46	48	45	33	37	27	n = 121
F	38	42	39	39	44	46	44	32	33	30	40	SE = 0.7
E	46	48	40	38	39	47	43	41	32	26	36	
D	48	46	42	47	43	48	31	42	47	40	46	
C	46	44	47	46	45	46	42	47	50	53	47	
B	52	50	47	51	50	52	59	64	52	57	50	
A	49	52	51	49	61	56	53	53	52	48	53	

Table 2. (cont.)

g) Location: Sagwon grid: MNT-1 (old)

Observers: Nathan Shoutis, Christine Martin

Date: 14 April 2004

Weather: sunny, slight wind, -5 °

C

	1	2	3	4	5	6	7	8	9	10	11	
K	29	41	39	41	37	44	23	38	28	26	32	
J	48	49	52	34	36	49	41	37	30	42	39	
I	46	52	65	55	58	42	53	36	38	35	42	mean = 48.0
H	51	51	48	59	42	51	54	40	37	40	32	SD = 9.0
G	46	51	60	59	47	54	43	54	45	53	61	n = 121
F	37	46	64	42	64	46	63	57	43	48	56	SE = 0.8
E	50	54	43	53	48	56	60	61	49	45	60	
D	54	49	58	40	59	60	52	50	46	60	51	
C	63	38	55	51	47	49	51	54	53	58	44	
B	48	52	53	51	44	47	55	60	65	52	42	
A	40	50	48	36	51	45	55	44	46	45	56	

h) Location: Sagwon grid: MNT 2 (new)

Observers: Nathan Shoutis, Christine Martin, Martha
Raynolds, Anja Kade

Date: 14 April 2004

Weather: sunny, slight wind -5° C

	1	2	3	4	5	6	7	8	9	10	11	
K	28	34	43	44	54	31	41	60	61	55	55	
J	45	45	21	40	35	32	56	41	51	54	59	
I	40	42	33	30	39	52	41	50	62	38	50	mean = 45.1
H	32	31	38	40	49	44	58	51	45	48	40	SD = 8.9
G	28	41	46	35	43	51	43	54	58	46	44	n = 121
F	35	45	44	37	44	36	42	52	37	54	34	SE = 0.8
E	37	39	39	46	41	42	39	56	47	56	35	
D	47	57	50	52	56	45	54	49	38	72	41	
C	39	50	35	52	40	48	42	49	34	40	36	
B	42	49	46	60	61	54	49	48	48	34	47	
A	51	38	43	41	66	58	50	44	44	55	36	

Remarks: Grid is oriented incorrectly, N is to left (not up).

Table 2. (cont.)

i) Location: Sagwon MAT

Observers: Nathan Shoutis, Martha Raynolds

Date: 16 April 2004

Weather: sunny, 10 mph breeze

	1	2	3	4	5	6	7	8	9	10	11	
K	34	43	39	41	43	38	48	50	67	63	52	
J	36	48	60	43	48	40	47	51	48	49	58	
I	38	30	31	46	30	49	51	50	50	52	49	mean = 47.4
H	42	51	46	54	51	56	30	56	57	52	49	SD = 8.2
G	33	45	38	45	54	50	51	40	52	49	42	n = 121
F	32	52	44	36	42	56	58	49	54	53	55	SE = 0.7
E	41	22	47	46	50	50	52	51	53	51	50	
D	40	42	56	41	55	53	61	41	51	49	49	
C	41	42	35	39	41	55	47	48	43	44	48	
B	48	48	57	40	56	59	48	49	55	55	51	
A	42	24	36	55	59	53	56	42	56	58	60	

j) Location: Happy Valley grid: Hilltop (dry)

Observers: Nathan Shoutis, Martha Raynolds

Date: 16 April 2004

Weather: sunny, slight breeze

	1	2	3	4	5	6	7	8	9	10	11	
K	35	29	52	57	44	39	49	38	36	43	48	
J	59	52	51	41	48	61	49	51	53	61	45	
I	42	39	46	46	58	35	44	36	33	55	55	mean = 50.3
H	47	55	50	49	51	37	44	43	56	48	50	SD = 7.7
G	51	49	50	59	54	44	53	30	50	51	53	n = 121
F	47	58	50	48	48	50	49	51	50	64	68	SE = 0.7
E	58	35	54	58	47	53	51	53	55	68	50	
D	48	49	48	51	56	42	43	55	60	55	63	
C	50	37	58	53	45	59	48	55	53	60	44	
B	52	56	58	54	39	57	40	48	47	60	60	
A	51	59	55	58	55	50	57	47	53	60	64	

Table 2. (cont.)

k) Location: Happy Valley grid: Mid-slope (moist)

Observers: Nathan Shoutis, Martha Raynolds

Date: 16 April 2004

Weather sunny, slight breeze

	1	2	3	4	5	6	7	8	9	10	11	
K	78	75	75	64	52	65	72	61	74	61	58	
J	79	73	62	65	72	73	71	66	64	73	75	
I	73	68	60	77	66	65	71	71	81	75	70	mean = 68.9
H	71	61	61	76	72	69	80	77	62	42	60	SD = 7.2
G	66	71	79	81	78	67	70	82	77	54	75	n = 121
F	56	70	79	66	79	66	66	63	64	59	72	SE = 0.7
E	75	73	77	70	73	66	74	68	71	60	69	
D	81	70	82	64	75	69	62	69	56	68	61	
C	85	74	77	71	68	57	61	65	66	66	60	
B	69	75	65	76	62	63	65	73	67	62	62	
A	77	72	69	77	63	68	67	64	72	67	62	

l) Location: Happy Valley, grid: Toe slope (wet)

Observers: Nathan Shoutis, Martha Raynolds

Date: 16 April 2004

Weather: sunny, slight breeze

	1	2	3	4	5	6	7	8	9	10	11	
K	78	78	64	71	78	56	60	63	71	63	67	
J	62	71	70	76	72	60	71	64	70	63	63	
I	53	71	78	74	83	84	79	59	64	71	62	mean = 67.1
H	71	77	71	62	60	79	65	65	77	61	65	SD = 6.6
G	69	62	52	67	68	77	62	62	53	58	62	n = 121
F	77	67	73	74	61	65	69	66	58	74	72	SE = 0.6
E	64	65	68	75	78	67	66	61	69	64	74	
D	63	65	63	60	72	63	65	77	67	56	62	
C	65	68	62	62	63	61	76	72	73	74	67	
B	65	65	73	63	59	70	66	71	66	60	51	
A	58	67	72	67	68	64	70	68	62	68	64	

Table 3. Detailed depth and density measured on the four sides of the 10 x 10 m Biocomplexity grids, April 2004.

Density was measured with a Federal snow corer (cross-sectional area of 11.464 cm²). For sites listing more than one measurement, density was obtained by averaging the depths and weights before calculating the snow density.

a) **Location:** Howe Island No data gathered due to oilfield access denied.

b) **Location:** West Dock No data gathered due to oilfield access denied.

c) **Location:** Deadhorse

Observers: Martha Raynolds, Nathan Shoutis

Date: 14 April 2004

Site	Orientation	Snow depth (cm)	Snow weight (g)	Snow density (g/cm ³)
DH	N	40	154	0.34
	E	(58, 53)	(227, 204)	0.34
	S	59	240	0.35
	W	53	160	0.26
<i>site average:</i>				0.32

d) **Location:** Franklin Bluffs

Observer: Martha Raynolds

Date: April 13, 2004

Site	Orientation	next to	Snow depth (cm)	Snow weight (g)	Snow density(g/cm ³)
FB dry	N	K5	35	123	0.31
	E	F11	(42, 41)	(145, 136)	0.30
	S	A5	24	70	0.25
	W	F1	(30, 29)	(97, 98)	0.29
<i>site average</i>					0.29
FB moist	N	K5	(30,31)	(71, 83)	0.22
	E	F11	42	127	0.26
	S	A5	38	101	0.23
	W	F1	36	91	0.22
<i>site average</i>					0.23
FB wet	N	K5	(48, 48)	(192, 183)	0.34
	E	F11	(40,42,41)	(174, 135,153)	0.33
	S	A5	(42, 43)	(105, 100)	0.21
	W	F1	(40, 41)	(108, 117)	0.24
<i>site average:</i>					0.28

Table 3. (continued)

e) Location: Sagwon MNT

Observer: Martha Reynolds

Date: 13 April 2004

Site	Orientation	next to	Snow depth (cm)	Snow weight (g)	Snow density(g/cm ³)
SagMNT1	N	K5	(31, 31)	(102, 108)	0.30
	E	F11	(50, 46, 46)	(196, 159, 169)	0.32
	S	A5	(50, 45)	(151, 152)	0.28
	W	F1	60	216	0.31
<i>site average:</i>					0.30
SagMNT2	N	F1	(30, 29)	(70, 75)	0.21
	E	K5	(44, 43)	(163, 150)	0.31
	S	F11	(35, 36)	(105, 119)	0.28
	W	A5	29	116	0.35
<i>site average:</i>					0.29
Sagwon MAT	N	F11	35	100	0.25
	E	A5	45	115	0.22
	S	F11	46	132	0.25
	W	K5	39	101	0.23
<i>site average:</i>					0.24

f) Location: Happy Valley

Observer: Christine Martin

Date: April 15, 2004

Site	Orientation	next to	Snow depth (cm)	Snow weight (g)	Snow density(g/cm ³)
HV dry	N	K5	48	109	0.20
	E	F11	45	137	0.27
	S	A5	29	112	0.34
	W	F1	38	99	0.23
<i>site average:</i>					0.26
HV moist	N	K5	66	200	0.26
	E	F11	70	252	0.31
	S	A5	66	190	0.25
	W	F1	61	175	0.25
<i>site average:</i>					0.27
HV wet	N	K5	66	165	0.22
	E	F11	49	141	0.25
	S	A5	71	162	0.20
	W	F1	57	127	.19
<i>site average:</i>					0.22

Table 4. Depth, snow water equivalent (SWE), and snow density at the Biocomplexity grids, April 2004.

Site	depth (cm) $\pm$ s.e.	density (g/cm ³) $\pm$ s.e.	SWE snow-water equivalent cm ³ (density*depth) $\pm$ s.e.
DH	51.9 $\pm$ 4.4	0.32 $\pm$ 0.02	16.8 $\pm$ 1.8
FBd	32.5 $\pm$ 3.7	0.29 $\pm$ 0.01	9.4 $\pm$ 1.3
FBm	36.6 $\pm$ 2.4	0.23 $\pm$ 0.01	8.6 $\pm$ 0.9
FBw	43.0 $\pm$ 1.7	0.28 $\pm$ 0.03	12.1 $\pm$ 1.7
SN1	46.5 $\pm$ 5.9	0.30 $\pm$ 0.01	14.1 $\pm$ 2.0
SN2	34.4 $\pm$ 3.4	0.29 $\pm$ 0.03	10.0 $\pm$ 1.5
SA	41.3 $\pm$ 2.6	0.24 $\pm$ 0.01	9.8 $\pm$ 0.7
HVd	40.0 $\pm$ 4.2	0.26 $\pm$ 0.03	10.0 $\pm$ 0.7
HVm	65.8 $\pm$ 1.8	0.27 $\pm$ 0.02	17.8 $\pm$ 1.5
HVw	60.8 $\pm$ 4.9	0.22 $\pm$ 0.01	13.0 $\pm$ 0.8

Remarks:

Measurements taken at 4 sides of each grid.

Table 5. Snow profiles at Biocomplexity grids, April 2004.

- a) **Location:** Deadhorse **Observer:** Anja Kade **Date:** 14 April 2004
Sky conditions: clear **Air temperature:** -20°C
Snow surface: rippled, sastrugi **Snow depth (cm):** boil = 27, interboil = 39
Surface roughness: random furrows, 15 cm depth, 4 m between ridges, E-W direction

Layer thickness (cm)	Grain shape	Grain size (mm)	Density (g/cm ³)	Temp (°C)	Hardness index	Remarks
Frost boil						
0-7	Hollow cup crystal	7		-19	Fist	Depth hoar
7-12	Rounded poly-crystal	1-2		-21	Knife	Wind slab? Refrozen!
12-27	Small rounded particle	0.5	0.38	-25	1 finger	
Interboil						
0-12	Hollow cup crystal	7		-19	Fist	Depth hoar
12-20	Rounded poly-crystal	1-2		-21	Knife	Hard layer, some metamorphosis
20-39	Small rounded particle	0.5	0.38	-25	1 finger	

Table 5 (continued)

- b) **Location:** Franklin Bluffs moist grid Observer: Anja Kade Date: 13 April 2004
Sky conditions: no clouds, little wind, sunny Air temperature: -13°C
Snow surface: sastrugi Snow depth (cm): boil = 24, interboil = 36
Surface roughness: random furrows, 5 cm depth, 1 m between ridges, E-W direction

Layer thickness (cm)	Grain shape	Grain size (mm)	Density (g/cm ³)	Temp (°C)	Hardness index	Remarks
Frost boil						
0-2	Faceted with recent rounding	2		-16	Pencil	Hard - particles frozen together
2-23	Rounded particles with few facets\	1		-18	Fist	Main snow pack
23-24	Wind crust - well sintered particles	0.5	0.26	-12	4 finger	Soft slab
Interboil						
0-9	Hollow cup crystal	7		-16	Fist	Depth hoar
9-13	Hollow cup crystal	5		-16	1 finger	Refrozen depth hoar
13-34	Rounded particles with few facets	1		-18	fist	Main snow pack
34-36	Wind crust - well sintered particles	0.5	0.26	-12	4 finger	Soft slab

- c) **Location:** Sagwon MNT 1 Observer: Anja Kade Date: 13 April 2004
Sky conditions: sunny, mild Air temperature: -3°C
Snow surface: pitted Snow depth (cm): 42
Surface roughness: smooth overall with random furrows, 2 cm depth, 0.5 m between ridges, E-W direction

Layer thickness (cm)	Grain shape	Grain size (mm)	Density (g/cm ³)	Temp (°C)	Hardness index	Remarks
0-6	Hollow cup crystal	8		-14	Fist	Loose depth hoar
6-8	Rounded particles with few facets	2		-15	Knife	Hard layer
8-11	Hollow cup crystal	7		-14	fist	Some loose depth hoar
11-19	Faceted with recent rounding	2	0.33	-13	4 fingers	Some plates, signs of metamorphosis
19-42	Well-rounded particles	0.5-1	0.37	-13	pencil	

Table 5 (continued)

Location: Sagwon MAT

Observer: Anja Kade

Date: 15 April 2004

Sky conditions: clear

Air temperature: -9°C

Snow surface: rippled

Snow depth (cm): 43

Surface roughness: random furrows, 4 cm depth, 0.4 m between ridges, E-W direction

Layer thickness (cm)	Grain shape	Grain size (mm)	Density (g/cm ³)	Temp (°C)	Hardness index	Remarks
0-16	Large cup-shaped hollow crystals in columns	10-20	0.26	-14	4 fingers	Depth hoar, clustered in columns
16-22	Faceted with recent rounding	2		-14	Pencil	Hard windslab
22	Horizontal buried ice layer					Ice layer, 0.5 cm thick
22-28	Hollow cup crystal	7		-13	4 fingers	Depth hoar
28-30	Faceted with recent rounding	2		-12	pencil	Hard windslab
30-43	Well-rounded particles	1	0.29	-11	4 fingers	Same surface snow as other sites

d) **Location:** Happy Valley

Observer: Anja Kade

Date: 15 April 2004

Sky conditions: sunny, mild

Air temperature: -5°C

Snow surface: smooth with few ripples

Snow depth (cm): 65

Surface roughness: smooth with slight E-W ridges, 5 cm depth

Layer thickness (cm)	Grain shape	Grain size (mm)	Density (g/cm ³)	Temp (°C)	Hardness index	Remarks
0-20	Hollow cup crystal, some arranged in columns	8	0.29	-10	4 fingers	Depth hoar
20-34	Hollow cup crystals and columns	1	0.31	-11	Fist	Metamorphosed crystals, but more compact and less "refrozen" than depth hoar
34-64	Well-rounded particles	1	0.29	-13	4 fingers	Same surface snow as other sites
64-65	Surface hoar frost	3		-7	Fist	Very pretty surface hoar

Table 6. Snow depths at Happy Valley 1 x 1 km grid, April 2004.

Northing	Easting	Stake	1	2	3	4	Mean	S.E	Northing	Easting	Stake	1	2	3	4	Mean	S.E
7,671,500	426,000	90	92	89	88	90	90	0.7	7,672,000	426,500	84	81	82	85	86	84	0.9
7,671,500	426,100	78	77	73	75	60	73	3.3	7,672,000	426,600	48	51	61	54	53	53	2.2
7,671,500	426,200	50	69	70	72	62	65	4.0	7,672,000	426,700	72	74	87	75	64	74	3.7
7,671,500	426,300	80	77	79	73	78	77	1.2	7,672,000	426,800	57	53	53	58	52	55	1.2
7,671,500	426,400	50	60	62	67	60	60	2.8	7,672,000	426,900	94	100	120	100	107	104	4.5
7,671,500	426,500	68	64	70	72	73	69	1.6	7,672,100	427,000	68	66	64	66	74	68	1.7
7,671,500	426,600	83	80	69	70	73	75	2.8	7,672,100	426,000	67	73	73	65	64	68	1.9
7,671,500	426,700	76	76	76	75	69	74	1.4	7,672,100	426,100	83	72	76	71	79	76	2.2
7,671,500	426,800	52	62	63	68	67	62	2.8	7,672,100	426,200	60cm 4m N of stake			Destroyed by seismic train			
7,671,500	426,900	132	130	117	136	126	128	3.2	7,672,100	426,300	72	83	67	70	85	75	3.6
7,671,500	427,000	57	35	53	47	37	46	4.3	7,672,100	426,400	85	84	84	81	73	81	2.2
7,671,600	426,000	100	105	102	89	99	99	2.7	7,672,100	426,500	43	55	48	45	59	50	3.0
7,671,600	426,100	74	84	82	84	84	82	1.9	7,672,100	426,600	67	65	55	61	61	62	2.1
7,671,600	426,200	60	60	56	56	58	58	0.9	7,672,100	426,700	72	65	72	63	70	68	1.9
7,671,600	426,300	68	71	65	68	68	68	0.9	7,672,100	426,800	53	46	62	55	65	56	3.4
7,671,600	426,400	72	72	72	69	71	71	0.6	7,672,100	426,900	75	73	78	63	72	72	2.5
7,671,600	426,500	53	63	58	64	69	61	2.7	7,672,200	426,000	62	71	64	65	69	66	1.7
7,671,600	426,600	92	88	90	79	86	87	2.2	7,672,200	426,100	74	65	66	67	62	67	2.0
7,671,600	426,700	80	73	72	70	70	73	1.8	7,672,200	426,200	69	68	71	66	70	69	0.9
7,671,600	426,800	62	65	72	71	65	67	1.9	7,672,200	426,300	50	65	57	58	57	57	2.4
7,671,600	426,900	42	40	33	40	41	39	1.6	7,672,200	426,400	64	62	66	64	62	64	0.7
7,671,600	427,000	64	42	52	47	65	54	4.6	7,672,200	426,500	67	64	65	60	65	64	1.2
7,671,700	426,000	39	29	51	27	34	36	4.3	7,672,200	426,600	52	62	62	56	55	57	2.0
7,671,700	426,100	59	68	67	60	73	65	2.6	7,672,200	426,700	59	51	67	64	68	62	3.1
7,671,700	426,200	70	75	76	70	71	72	1.3	7,672,200	426,800	69	70	76	64	69	70	1.9
7,671,700	426,300	43	46	41	47	51	46	1.7	7,672,200	426,900	73	67	76	72	68	71	1.7
7,671,700	426,400	64	55	72	66	62	64	2.8	7,672,200	427,000	80	79	77	72	69	75	2.1
7,671,700	426,500	90	84	85	85	85	86	1.1	7,672,300	426,000	68	69	70	62	60	66	2.0
7,671,700	426,600	72	69	77	70	63	70	2.3	7,672,300	426,100	76	74	80	74	77	76	1.1
7,671,700	426,700	67	71	85	72	66	72	3.4	7,672,300	426,200	69	69	67	70	74	70	1.2
7,671,700	426,800	57	63	57	56	59	58	1.2	7,672,300	426,300	66	64	58	66	64	64	1.5
7,671,700	426,900	57	58	63	64	56	60	1.6	7,672,300	426,400	64	66	68	64	64	65	0.8
7,671,700	427,000	48	45	58	57	47	51	2.7	7,672,300	426,500	66	64	70	69	66	67	1.1
7,671,800	426,000	57	43	56	53	67	55	3.9	7,672,300	426,600	59	64	62	57	58	60	1.3
7,671,800	426,100	58	62	56	66	70	62	2.6	7,672,300	426,700	59	58	58	57	67	60	1.8
7,671,800	426,200	60	61	56	64	71	62	2.5	7,672,300	426,800	69	80	73	60	66	70	3.4
7,671,800	426,300	70	63	70	63	78	69	2.8	7,672,300	426,900	74	70	70	74	76	73	1.2
7,671,800	426,400	59	62	60	58	62	60	0.8	7,672,300	427,000	79	77	78	73	77	77	1.0
7,671,800	426,500	80	80	73	83	83	80	1.8	7,672,400	426,000	70	64	73	68	68	69	1.5
7,671,800	426,600	84	78	72	73	70	75	2.5	7,672,400	426,100	73	77	58	68	68	69	3.2
7,671,800	426,700	117	98	99	114	97	105	4.3	7,672,400	426,200	72	59	67	61	64	65	2.3
7,671,800	426,800	70	65	66	63	67	66	1.2	7,672,400	426,300	69	75	68	66	73	70	1.7

Table 6 (continued)

Northing	Easting	Stake	1	2	3	4	Mean	S.E	Northing	Easting	Stake	1	2	3	4	Mean	S.E
7,671,800	426,900	NA	NA	NA	NA	NA	Snowcat trail		7,672,400	426,400	67	67	63	68	70	67	1.1
7,671,800	427,000	51	50	53	50	48	50	0.8	7,672,400	426,500	59	59	60	61	50	58	2.0
7,671,900	426,000	84	74	73	83	78	78	2.2	7,672,400	426,600	70	67	65	59	67	66	1.8
7,671,900	426,100	65	66	77	77	70	71	2.6	7,672,400	426,700	71	66	76	69	73	71	1.7
7,671,900	426,200	79	75	79	67	72	74	2.3	7,672,400	426,800	64	66	69	58	62	64	1.9
7,671,900	426,300	66	64	68	71	72	68	1.5	7,672,400	426,900	67	63	65	61	69	65	1.4
7,671,900	426,400	64	68	66	56	64	64	2.0	7,672,400	427,000	76	77	72	77	82	77	1.6
7,671,900	426,500	61	62	63	68	70	65	1.8	7,672,500	426,000	65	60	71	62	62	64	1.9
7,671,900	426,600	63	62	65	58	60	62	1.2	7,672,500	426,100	76	59	59	67	59	64	3.4
7,671,900	426,700	49	56	49	46	48	50	1.7	7,672,500	426,200	70	64	64	62	55	63	2.4
7,671,900	426,800	73	70	72	73	75	73	0.8	7,672,500	426,300	62	45	67	57	64	59	3.9
7,671,900	426,900	85	81	80	80	78	81	1.2	7,672,500	426,400	71	70	69	70	65	69	1.0
7,671,900	427,000	27	26	29	23	29	27	1.1	7,672,500	426,500	65	65	61	58	53	60	2.3
7,672,000	426,000	75	76	72	69	70	72	1.4	7,672,500	426,600	76	75	85	67	78	76	2.9
7,672,000	426,100	71	63	70	82	77	73	3.2	7,672,500	426,700	75	77	71	70	71	73	1.4
7,672,000	426,200	71	73	80	80	71	75	2.1	7,672,500	426,800	73	71	67	69	72	70	1.1
7,672,000	426,300	65	63	73	65	66	66	1.7	7,672,500	426,900	88	72	67	73	75	75	3.5
7,672,000	426,400	60 cm 2 m N of stake				Destroyed by seismic train			7,672,500	427,000	88	72	74	74	77	77	2.9

Grid mean = 68.0 +/- 1.2 cm

Table 7. Snow depths at Happy Valley permanent plots, April 2004.

Relevé	Latitude (mm d ss.s)			Longitude (mm dd ss.s)			Stake	1	2	3	4	Mean	Standard Error
1	69	9	28.6	148	49	13.8	42	49	48	43	44	45	1.4
2	69	9	28.4	148	49	18.3	30	28	33	35	32	31.6	1.2
3	69	9	37.5	148	49	28.4	75	81	73	75	70	74.8	1.8
4	69	9	29.7	148	49	29.8	74	80	83	84	71	78.4	2.5
5	69	9	28.8	148	49	31.7	80	83	80	80	100	84.6	3.9
6	69	9	24.8	148	49	25.5	47	48	50	47	49	48.2	0.6
7	Unable to locate												
8*							17	23	23	28	25	23.2	1.8
9	69	8	48.3	148	49	44.2	45	49	37	43	46	44	2.0
10	69	8	48.4	148	49	38.6	47	45	47	53	52	48.8	1.6
11	Unable to locate												
12							Approx. 100						
13	Unable to locate												
14*	69	8	16.3	148	49	59.1	40	48	50	50	54	48.4	2.3
15	Unable to locate												
16	Unable to locate												
17	69	7	31.2	148	49	57	53	57	53	42	33	47.6	4.4
18	69	7	23.6	148	49	56.6	45	45	48	45	45	45.6	0.6

Table 7 (continued)

Relevé	Latitude (mm d ss.s)			Longitude (mm dd ss.s)			Stake	1	2	3	4	Mean	Standard Error
19	Unable to locate												
20	69	9	30	148	50	13.8	66	63	59	72	53	62.6	3.2
21	69	9	33.3	148	50	14.7	70	70	60	72	72	68.8	2.2
22*	69	9	34.1	148	50	15.3	240						
23*	69	9	35.3	148	50	15.3	61	66	62	65	70	64.8	1.6
24*	69	9	36.3	148	50	74.9	92	90	100	97	102	96.2	2.3
25	69	9	36.7	148	50	15	67	66	75	68	71	69.4	1.6
26	69	9	37.1	148	50	15.1	55	58	58	60	54	57	1.1
27	69	9	39.7	148	50	15	69	65	67	74	65	68	1.7
28	69	9	42.2	148	50	16.1	78	66	76	81	74	75	2.5
29	69	9	48.3	148	50	18.9	71	68	70	73	81	72.6	2.2
30	69	9	68.1	148	50	34.5	55	42	41	50	51	47.8	2.7
31	69	8	55.7	148	50	44.3	69	67	63	67	63	65.8	1.2
32	69	8	46.5	148	50	21.1	62	63	66	60	64	63	1.0
33	69	8	47	148	51	24.3	51	55	55	55	57	54.6	1.0
34	69	8	47.9	148	51	27.9	67	68	71	66	67	67.8	0.9
35	69	8	48.9	148	51	28.5	57	61	57	58	58	58.2	0.7
36	69	8	48.5	148	51	29	65	61	63	58	62	61.8	1.2
37	69	8	48.6	148	51	29.8	59	56	66	61	64	61.2	1.8
38	69	8	48.6	148	51	30.4	53	61	62	56	59	58.2	1.7
39	69	8	49.4	148	51	33.2	76	70	77	71	65	71.8	2.2
40	69	8	45.6	148	51	40.2	62	59	54	58	60	58.6	1.3
41	Unable to locate												
42	69	8	44.2	148	51	4.3	80	80	71	76	86	78.6	2.5
43	69	8	41.1	148	50	50.6	95	78	82	82	88	85	3.0
44	69	8	40.6	148	50	33.9	48	44	56	55	66	53.8	3.8
45	69	8	45.9	148	50	35	40	51	51	31	42	43	3.8
46	69	9	56.2	148	51	19.4	61	58	60	62	59	60	0.7
47	69	9	55.1	148	51	19.6	49	47	50	49	49	48.8	0.5
48	Unable to locate												
49	69	9	56.2	148	51	32.1	35	39	31	36	36	35.4	1.3
50	69	9	57.3	148	51	37.5	40	42	42	41	39	40.8	0.6
51	Unable to locate												
52	69	9	54.1	148	52	3.6	63	62	62	56	64	61.4	1.4
53	69	9	53.2	148	52	6.5	61	58	58	60	64	60.2	1.1
54	69	9	56.5	148	51	44.2	48	48	49	46	46	47.4	0.6
55	69	9	57.3	148	51	42.7	42	41	42	38	41	40.8	0.7

Figures

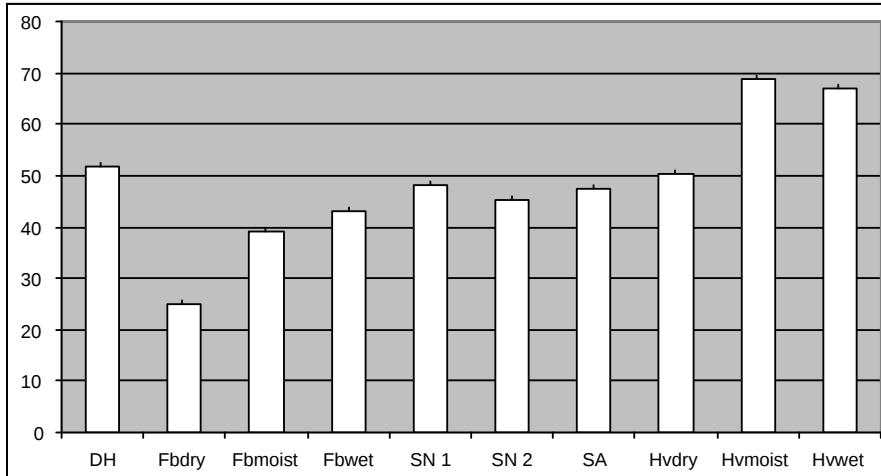


Figure 1. Mean snow depth (cm) on 10 x 10 m grids, North Slope, Alaska, April 2004 (n = 121).

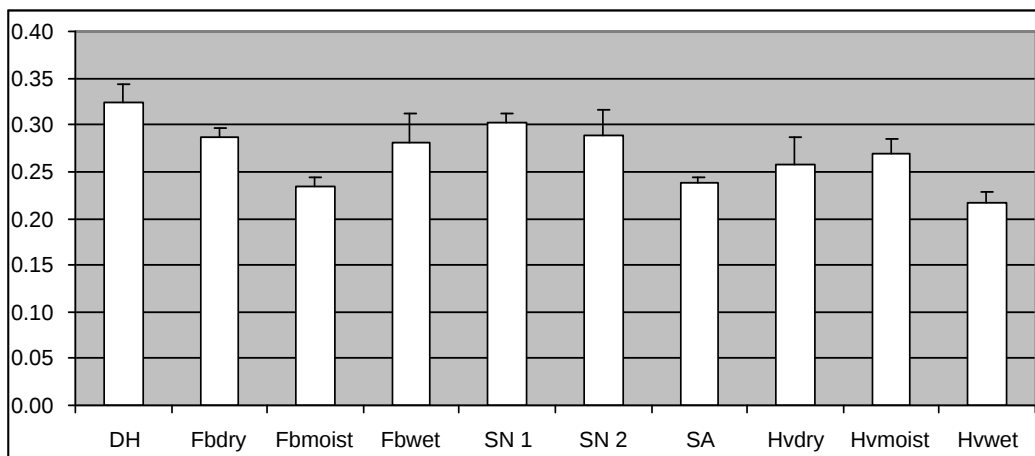


Figure 2. Mean snow density (g/cm^3 +/- s.e.) on 10 x 10 m grids, North Slope, Alaska, April 2004 (n = 4).

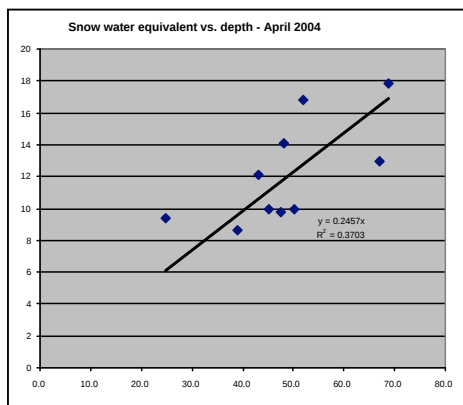


Figure 3. Snow water equivalent vs. snow depth from ten 10 x 10 m grids on the North Slope, Alaska, April 2004.

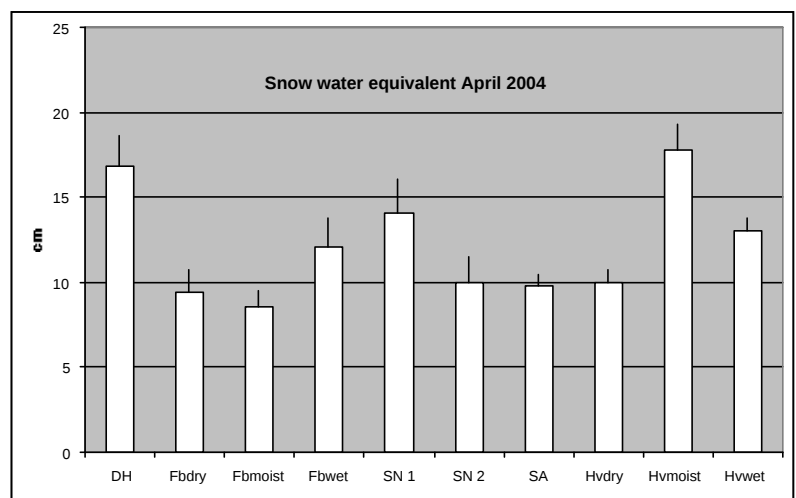


Figure 4. Snow water equivalent on 10 x 10 m grids on the North Slope, Alaska, April 2004 (n = 4).

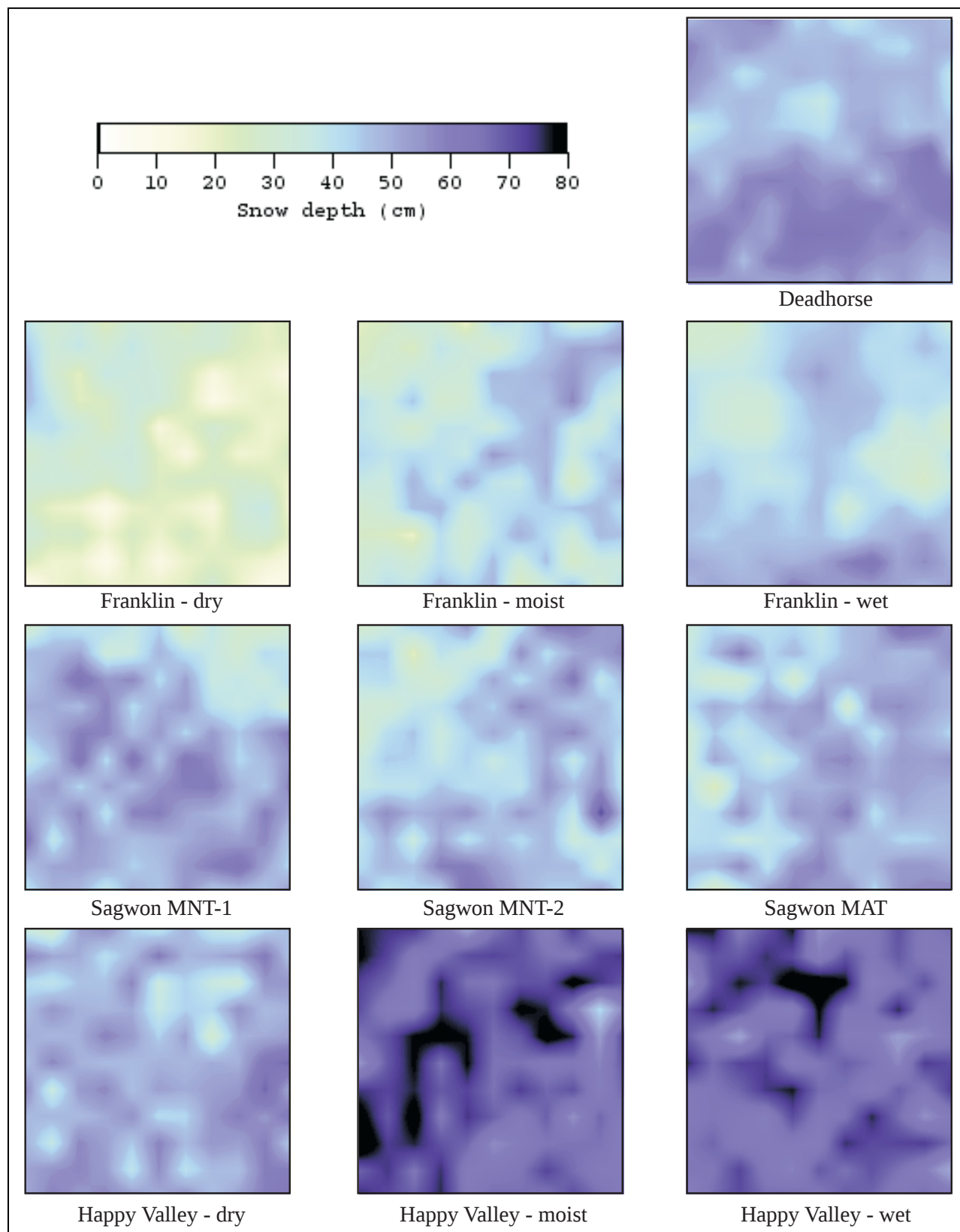


Figure 5. Snow depths of the 10 x 10 m grids, North Slope, Alaska, April 2004.

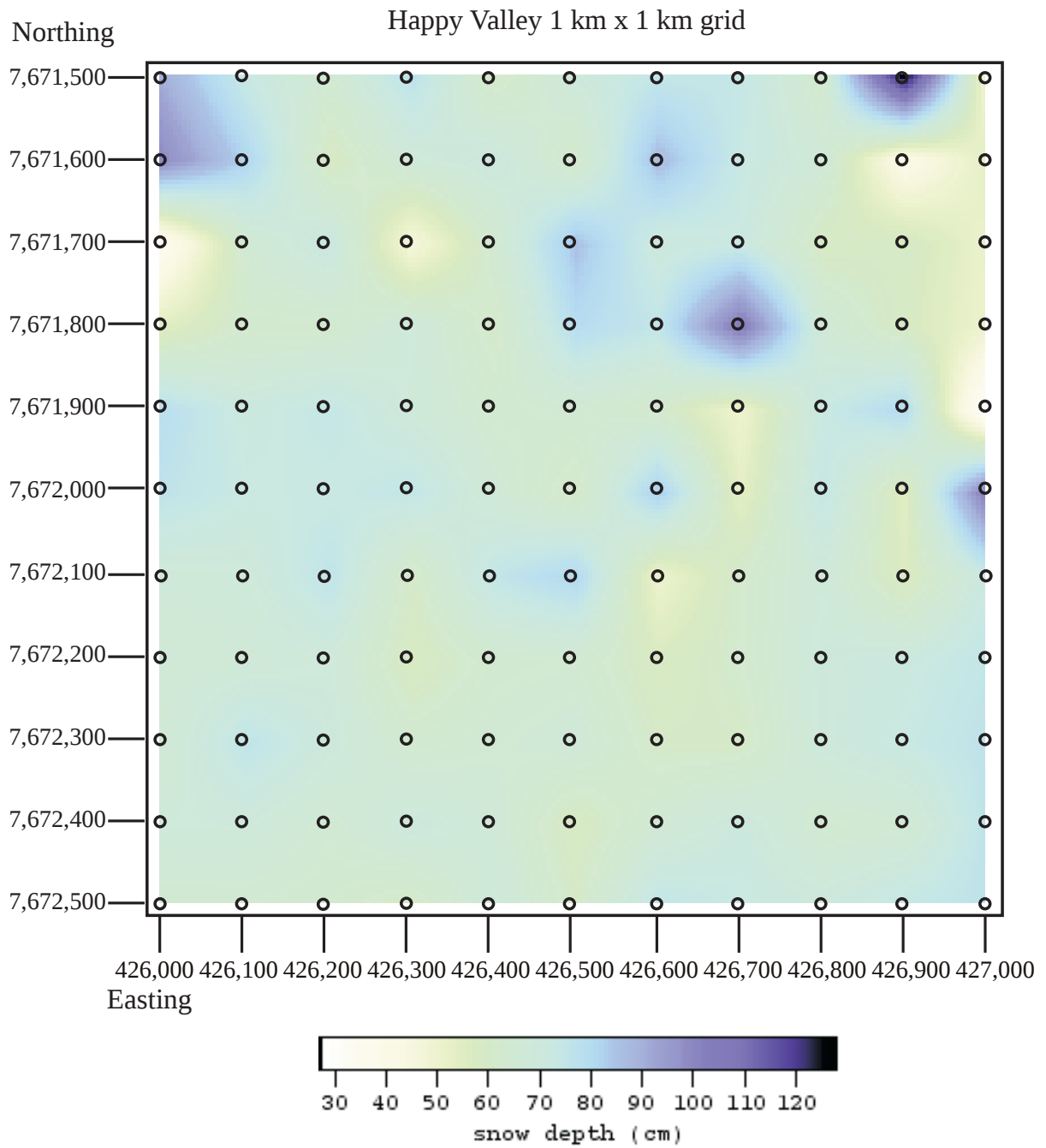


Figure 6. Snow depths on Happy Valley 1 km x 1 km grid, May 2004

Appendix A. Photographs



Photo 1. Christine Martin measuring snow depth. Photo by M.K. Raynolds



Photo 2. Martha Raynolds coring snow for density measurements. Photo by C. R. Martin.

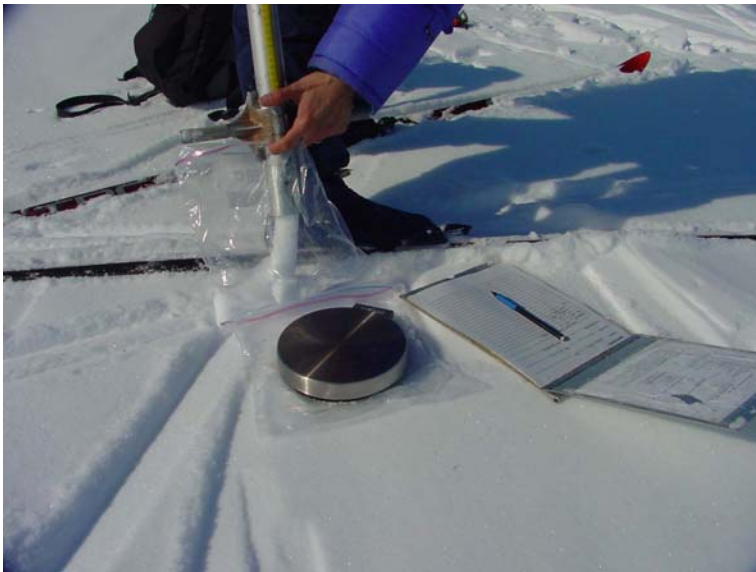


Photo 3. Christine Martin weighing snow from corer. Photo by M. K. Raynolds



Photo 4. Anja Kade measuring heave at frost boil. Photo by M. K. Raynolds

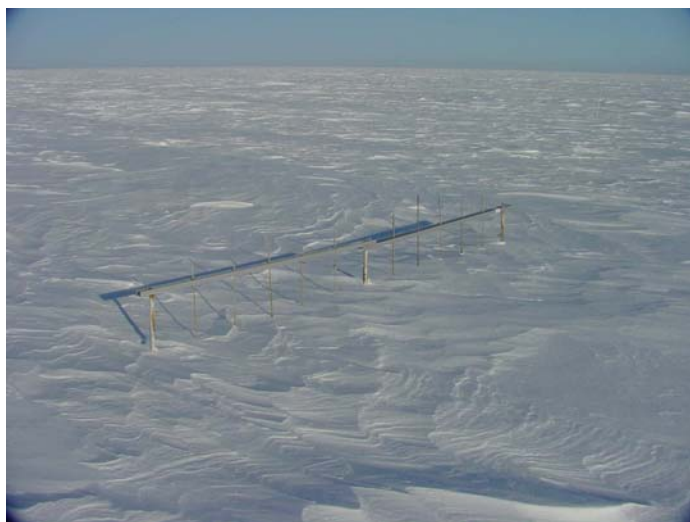


Photo 5. Heave-meter at Franklin Bluff moist grid. Photo by M. K. Raynolds



Photo 6. Snow pit at Deadhorse grid; note hard snow slab on surface with depth hoar below. Photo by M. K. Raynolds



Photo 7. Snow pit at Franklin Bluff moist grid; note depth-hoar layer, which is shallower on top of the frost boil on the right. Photo by M. K. Raynolds



Photo 8. Snow pit at Happy Valley; note deep, light snow. Photo by M. K. Raynolds

Appendix B. Data collection forms

SNOW DENSITY

Location: _____ Grid: _____

Observers: _____ Date: _____

Coring equipment: _____ Corer cross-section: _____

Sample site	Snow depth (cm)	Snow weight (g)	Notes

SNOW DEPTH (cm) - GRID SAMPLE

Location: _____ Grid: _____

Observers: _____ Date: _____

Weather: _____ Photo: _____

	1	2	3	4	5	6	7	8	9	10	11	
K												K
J												J
I												I
H												H
G												G
F												F
E												E
D												D
C												C
B												B
A												A
	1	2	3	4	5	6	7	8	9	10	11	

*Note: be careful about putting data in correct order/location, with A1 in lower left
this will match maps of the grid, and put approximate North to the top of the page*

Remarks:

SNOW PROFILE

Location: _____

Grid: _____

Observers: _____

Date & Time: _____

Sky conditions: _____

Air Temp (°C): _____

SNOW SURFACE (Circle one)			
Smooth	Rippled	Pitted	Gullied

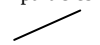
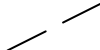
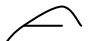
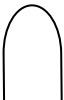
SURFACE ROUGHNESS (circle one)				
Smooth	Wavy	Concave furrows	Convex furrows	Random furrows
Average depth of surface irregularities: _____				
Average wavelength (distance between ridges): _____				
Compass direction of ridges: _____				

Total snow depth (cm): _____

Layer	Thickness (cm)	Grain Shape (see crystal classification table)	Grain Size (mm)	Density (g/cm ³)	Temp (°C)	Hardness Index (see table)	Remarks
Top 1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

Appendix C. Classification of snow crystals (Colbeck et al. 1992)

Classification of snow crystals (Colbeck et al. 1992)

Precipitation particles	Columns 	Short prismatic crystal, solid or hollow	Decomposing and fragmented precipitation particles	Partly decomposed particles 	Partly rounded, characteristic shapes of precip. particles still recognizable	Cup-shaped crystals, depth hoar	Cup crystal 	Cup-shaped, striated crystals, usually hollow	Ice masses	Ice layer 	Horizontal buried ice layer
	Needles 	Needle-like, approx. cylindrical		Highly broken particles 	Packed, shards or rounded fragments of precip. particles		Columns of depth hoar 	Large cup-shaped striated hollow crystals arranged in columns <10mm		Ice column 	Vertical ice body
	Plates 	Plate-like, mostly hexagonal	Rounded grains	Small rounded particles 	Well rounded particles, <0.5 mm, often well bonded		Columnar crystals 	Very large columnar crystals, 10-20 mm		Basal ice 	Basal ice layer
	Stellar dendrites 	Six-fold, star-like, planar or spatial		Large rounded particles 	Well rounded particles > 0.5 mm	Wet grains	Clustered rounded grains 	Clustered rounded crystals held by large ice-ice bonds, water in veins between grains	Surface deposits and crusts	Rime 	Soft rime: irregular Hard rime: small super-cooled water droplets frozen in place
	Irregular crystals 	Cluster of very small crystals		Mixed form 	Rounded particles, with few developing facets		Rounded poly-crystals 	Individual crystals frozen into solid poly-crystalline grain, wet or re-frozen		Rain crust 	Thin, transparent glaze or clear surface layer
	Graupel 	Heavily rimed particles	Faceted crystals	Solid faceted particles 	Solid faceted crystals, usually hexagonal prisms		Slush 	Separate rounded crystals completely immersed in water		Sun crust, firm-spiegel 	Thin, transparent glaze or surface film
	Hail 	Laminar internal structure, translucent or milky, glazed surface		Small faceted particles 	Small faceted crystals in surface layer; <0.5 mm	Feathery crystals	Surface hoar frost 	Striated, usually feathery crystal; aligned; usually flat, sometimes needle-like		Wind crust 	Small, broken or abraded, closely-packed particles, well-sintered
	Ice pellets 	Transparent, mostly small spheroids		Mixed forms 	Faceted particles with recent rounding of facets		Cavity hoar 	Striated, planar or feathery crystals grown in cavity, random orientation		Melt-freeze crust 	Crust of recognizable melt-freeze polycrystals

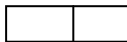
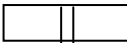
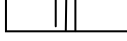
Hardness of deposited snow (Colbeck et al. 1992)

<i>Term</i>	<i>Swiss Rammsonde (newtons)</i>	<i>Order of magnitude stress (Pa)</i>	<i>Hand test</i>	<i>Symbol</i>	<i>Graphic symbol</i>
Very low	0-20	0-103	Fist	R1	
Low	20-150	103-104	4 fingers	R2	/
Medium	150-500	104-105	1 finger	R3	X
High	500-1000	105-106	Pencil	R4	//
Very high	> 1000	> 106	Knife blade	R5	XXX
Ice				R6	■

Load-bearing capacity of the snow surface (Colbeck et al. 1992)

Depth of ski track (skier supported on one ski) in mm
Depth of footprint (person standing on one foot) in mm
Penetration of a Swiss Rammsonde (first element by its own weight)

Liquid water content (Colbeck et al. 1992)

<i>Term</i>	<i>Remarks</i>	<i>Approximate Range</i>	<i>Symbol</i>
Dry	Dry snow can occur at any temperature up to 0°C. Disaggregated snow grains have little tendency to adhere to each other when pressed together, as in making a snowball.	0%	
Moist	T = 0°C. Water is not visible even at 10 x magnification. When lightly crushed, the snow has a distinct tendency to stick together.	< 3%	
Wet	T = 0°C. Water can be recognized at 10 x magnification by its meniscus between adjacent snow grains, but water cannot be pressed out by moderately squeezing the snow in the hands.	3-8%	
Very wet	T = 0°C. Water can be pressed out by moderately squeezing the snow in the hands, but there is an appreciable amount of air confined within the pores.	8-15%	
Slush	T = 0°C. Snow is flooded with water and contains relatively small amounts of air.	> 15%	