# Biocomplexity of Frost-Boil Ecosystems

## Data Report:
## Snow on the Alaska North Slope Grids
## April 2003

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

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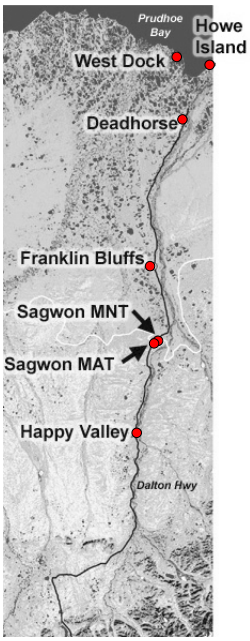
Cover Page Photograph

Ice crust formed by midwinter rain event at Howe Island; climate station in background. Photographed by Skip Walker.




# Biocomplexity of Frost-Boil Ecosystems

## 2003 Snow Data Report at Alaska North Slope Biocomplexity Sites

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

## Introduction

This data report is a summary of snow-survey information collected during a trip to the Arctic Slope April 9-14, 2003. The data were all collected as part of the Biocomplexity of Frost-Boil Ecosystems study (Walker et al. 2003, in press). 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 Dr. D.A. (Skip) Walker, Mr. Hilmar Maier, Ms. Anja Kade, and Ms. Corinne Munger, all from the Alaska Geobotany Center, and Dr. Dmitri Sergueev, from the Geophysical Institute, University of Alaska Fairbanks.

The data collected included

1. Snow depth and soil temperature information from 106 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 twelve 10x10-m grids at Happy Valley, Sagwon, Franklin Bluffs, Deadhorse, West Dock, and Howe Island.
3. Snow depths at every meter within the grids.
4. Snow profile descriptions from each grid.

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.

Additional climate and snow data were collected by Dmitri Sergueev in conjunction with Vladimir Romanovsky's climate stations and heave instruments. These data can be obtained from Vlad Romanovsky, ffver@aurora.alaska.edu. Photos from the survey are in Appendix A.

## Methods

### Relevé snow depth and soil surface temperatures

Snow depth and soil surface temperature were measured on each relevé at the plot marker using a 0.25 inch (7 mm) diameter carbon fiber rod with metric tape and steel tip, with a thermister at the bottom end and an Omega Model 865/866 digital thermometer attachment on the top end. The snow depth/ soil surface temperature instrument was loaned to us by Matthew Sturm and was manufactured by John Holmgren, Fairbanks, AK. One measurement was taken at each plot marker. Table 1 contains the relevé snow depth and soil surface temperatures.

**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 $cm^2$. 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 and placed into a plaster bag and later weighed. One sample was taken at the midpoint of each side of the grids (4 samples per grid). The exception was Howe Island where only one measurement was taken on the north side of the grid. Appendix B contains the data sheet used for the data collection. The federal sampler was borrowed from Matthew Sturm, US Army CRREL, Ft. Wainwright, AK.

The locations and details of the measurements are in Table 2 (a - f). A summary of the average snow depths, snow density and SWE at each grid is in Table 3. The snow density was greatest at Franklin Bluffs, and least at West Dock and Happy Valley (Figure 1). Thin ice layers on the snow surface that prevented formation of a wind slab caused the relatively low values at West Dock. All the snow below the ice layers was loose-grained depth hoar. The ice layers were apparently formed during midwinter rain events. Snow water equivalent was plotted as a function of snow depth (Figure 2).

**Grid snow depths**

Snow depth was measured at every meter in each grid. If the pin flags marking the grid point locations were visible, the measurements were taken immediately adjacent to the pin flags. If the flags were buried by snow, 1 m intervals were marked on the A1 to K1 and the A11 to K11 sides of the grid with pin flags. 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 snow density measurements. The data sheet used for the grid snow depths is in Appendix C.

Table 4 (a - l) 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 3. Figure 4 shows the temperatures of the soil surface at the different sites; it is measured in the same way as were the relevés in Table 1. Maps of the snow depth on each grid are in Figure 5. The maps were made using the program Transform PPC version 3.4 by Fortner Software.
The deepest snow occurred at the Happy Valley wet (toeslope) site (64 ± 7 cm), and the shallowest snow was at Howe Island (6 ± 2 cm). The snow depths generally increased from the coast inland (Figure 3), but unusually deep snow was encountered at Deadhorse (51 ± 10 cm).

**Snow profiles**

Snow trenches were dug 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), Temperature was measured for the major layers in the profile using small digital thermometers. A sample of snow was taken from each of the major layers using a 487.25 $cm^3$ steel tube (provided by Dmitri Sergueev). The tube was carefully inserted into the snow layer until the snow filled the tube. A rubber lid was placed over the exposed front end of the tube. The snow at the buried end of the tube was then carefully exposed and a rubber lid placed over the tube. The

snow was then removed from the corer and placed into a plaster bag and later weighed. See Appendix D for the snow profile data sheet and Appendix E for classification of snow characteristics.

Thin hard ice layers were noted in all the snow profiles and probably were formed during mid-winter rain events. These layers played a particularly important role in the development of the snow pack at the arctic coasts, where a smooth glazed surface prevented accumulation of more snow in the continuously windy environment. Snow beneath the ice layer underwent metamorphosis to form a continuous thick layer of depth hoar with large cup-shaped crystals.

**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. Raynolds, and V. E. Romanovsky. 2003 in press. Biocomplexity of frost-boil ecosystems: a conceptual model of morphology in relation to vegetation along a bioclimate gradient. *Permafrost and Periglacial Processes.*

**Acknowledgements**

Thanks to 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 depth and soil surface temperatures**

Date: April 10-12, 2003 Observer: Anja Kade

| Relevé | Location | Type | Snow depth (cm) | Soil surface temp. (˚C) | GPS (dd mm ss.s) |
|---|---|---|---|---|---|
| 1 | Franklin Bluffs | bare boil, wet | 16 | -12.5 | 69 40 26.7 148 42 58.4 |
| 2 | Franklin Bluffs | bare boil, wet | 12 | -12.2 | 69 40 25.9 148 43 01.8 |
| 3 | Franklin Bluffs | bare boil, wet | 14 | -12.9 | 69 40 27.1 148 43 02.4 |
| 4 | Franklin Bluffs | bare boil, wet | 21 | -14.1 | 69 40 26.3 148 43 07.5 |
| 5 | Franklin Bluffs | vegetated boil, dry | 8 | -11.4 | 69 40 28 148 43 13 |
| 6 | Franklin Bluffs | bare boil, dry | 3 | -10 | 69 40 29 148 43 16 |
| 7 | Franklin Bluffs | vegetated boil, dry | 15 | -15.2 | 69 40 30 148 43 16 |
| 8 | Franklin Bluffs | vegetated boil, dry | 9 | -13.6 | 69 40 27.5 148 43 13.9 |
| 9 | Franklin Bluffs | bare boil, dry | 6 | -12 | 69 40 27.4 148 43 13.9 |
| 10 | Franklin Bluffs | bare boil, dry | 2 | -7.8 | 69 40 26.3 148 43 13.7 |
| 11 | Franklin Bluffs | interboil dry | 14 | -15.7 | 69 40 27.4 148 43 13.8 |
| 12 | Franklin Bluffs | interboil dry | 22 | -15.8 | 69 40 28 148 43 14 |
| 13 | Franklin Bluffs | interboil dry | 13 | -14.6 | 69 40 29 148 43 15 |
| 14 | Franklin Bluffs | interboil wet | 40 | -14.6 | 69 40 25.9 148 43 01.8 |
| 15 | Franklin Bluffs | interboil wet | 38 | -14.6 | 69 40 27.1 148 43 02.4 |
| 16 | Franklin Bluffs | interboil wet | 29 | -13.9 | 69 40 26.7 148 42 58.4 |
| 17 | Franklin Bluffs | interboil wet | 38 | -12.8 | 69 40 26.3 148 43 07.5 |
| 18 | Franklin Bluffs | interboil, moist | 21 | -14.8 | 69 40 28.4 148 43 18.2 |
| 19 | Franklin Bluffs | interboil, moist | 11 | -14.5 | 69 40 29.2 148 43 17.5 |
| 20 | Franklin Bluffs | interboil, moist | 15 | -13.4 | 69 40 29.5 148 43 18.2 |
| 29 | Sagwon MNT | interboil moist | 33 | -17.6 | 69 26 00.9 148 40 16.8 |
| 30 | Franklin Bluffs | vegetated boil, dry | 2 | -6.8 | 69 40 28.9 148 43 15.7 |
| 31 | Franklin Bluffs | bare boil, dry | 2 | -8.8 | 69 40 28.9 148 43 15.7 |
| 32 | Franklin Bluffs | vegetated boil, dry | 6 | -11.7 | 69 40 28.2 148 43 14.0 |
| 33 | Franklin Bluffs | bare boil, dry | 1 | -8.1 | 69 40 28.4 148 43 14.5 |
| 34 | Franklin Bluffs | interboil dry | 12 | -15 | 69 40 28.9 148 43 14.8 |
| 35 | Franklin Bluffs | interboil dry | 8 | -11.2 | 69 40 28.5 148 43 14.4 |
| 36 | Franklin Bluffs | bare boil, wet | 15 | -11.2 | 69 40 25.7 148 43 28.4 |
| 37 | Franklin Bluffs | interboil wet | 32 | -13.8 | 69 40 25.9 148 43 28.8 |
| 38 | Deadhorse | vegetated boils | 71 | -13.5 | 70 09 40.8 148 28 00.5 |
| 39 | Deadhorse | vegetated boils | 30 | -11.5 | 70 09 37.2 148 28 10.05 |
| 40 | Deadhorse | vegetated boils | 42 | -12.9 | 70 09 41.5 148 27 59.0 |
| 41 | Deadhorse | vegetated boils | 37 | -13.2 | 70 09 41.9 148 27 59.5 |
| 42 | Deadhorse | vegetated boils | 59 | -13.3 | 70 09 38.5 148 28 08.7 |
| 43 | Deadhorse | bare frost boils | 27 | -11.2 | 70 09 41.5 148 27 59.7 |
| 44 | Deadhorse | bare frost boils | 36 | -13.3 | 70 09 38.6 148 28 08.6 |

**Table 1**. **(continued)**

| Relevé | Location | Type | Snow depth (cm) | Soil surface temp. (˚C) | GPS (dd mm ss.s) |
|---|---|---|---|---|---|
| 45 | Deadhorse | bare frost boils | 59 | -13.5 | 70 09 42.5 148 28 00.0 |
| 46 | Franklin Bluffs | interboil, moist | 18 | -12.9 | 69 40 28.4 148 43 16.5 |
| 47 | Franklin Bluffs | interboil, moist | 34 | -13.8 | 69 40 20.3 148 43 29.8 |
| 48 | Deadhorse | interboil moist | 37 | -11.9 | 70 09 41.6 148 28 00.0 |
| 49 | Deadhorse | interboil moist | 75 | -14.3 | 70 09 42.6 148 28 00.5 |
| 50 | Deadhorse | interboil moist | 49 | -12.4 | 70 09 38.3 148 28 09.2 |
| 51 | Deadhorse | interboil moist | 33 | -12.8 | 70 09 38.2 148 28 08.1 |
| 52 | Happy Valley | bare frost boil, wet | 51 | -11 | 69 08 49.8 148 50 49.1 |
| 53 | Happy Valley | bare frost boil, wet | 38 | -12.2 | 69 08 50.1 148 50 48.7 |
| 54 | Happy Valley | bare frost boil, wet | 45 | -11.1 | 69 08 48.8 148 50 49.7 |
| 55 | Sagwon MNT | interboil moist | 38 | -15.8 | 69 25 59.8 148 40 22.0 |
| 56 | Happy Valley | bare frost boil, wet | 64 | -9.9 | 69 08 48.7 148 50 48.9 |
| 58 | Sagwon MNT | vegetatated boil | 26 | -17.1 | 69 25 58.7 148 40 23.9 |
| 57 | Happy Valley | bare frost boil, wet | 51 | -10.4 | 69 08 49.1 148 50 49.3 |
| 59 | Sagwon MNT | vegetatated boil | 30 | -15.9 | 69 25 58.8 148 40 23.8 |
| 60 | Sagwon MNT | vegetatated boil | 24 | -16.3 | 69 25 59.3 148 40 21.7 |
| 61 | Sagwon MNT | vegetatated boil | 28 | -16.5 | 69 25 57.5 148 40 23.2 |
| 62 | Sagwon MAT | interboil moist | 18 | -19.5 | 69 25 32.0 148 41 45.3 |
| 63 | Sagwon MNT | bare boil | 27 | -15.9 | 69 25 58.8 148 40 23.1 |
| 64 | Sagwon MNT | vegetatated boil | 37 | -15.6 | 69 25 58.3 148 40 23.8 |
| 65 | Sagwon MNT | interboil moist | 39 | -17.3 | 69 25 58.5 148 40 23.3 |
| 66 | Happy Valley | interboil moist | 64 | -10.3 | 69 08 48.6 148 50 52.4 |
| 67 | Sagwon MNT | interboil moist | 27 | -18.3 | 69 25 54.1 148 40 22.5 |
| 68 | Sagwon MNT | interboil moist | 42 | -16.2 | 69 25 59.8 148 40 19.5 |
| 69 | Sagwon MNT | bare boil | 27 | -17.5 | 69 25 59.1 148 40 22.3 |
| 70 | Sagwon MNT | bare boil | 26 | -16.5 | 69 25 56.1 148 40 19.3 |
| 71 | Sagwon MNT | bare boil | 30 | -18.1 | 69 25 56.5 148 40 21.6 |
| 72 | Sagwon MNT | bare boil | 25 | -17.6 | 69 25 58.2 148 40 23.4 |
| 73 | Sagwon MAT | vegetated boil (mound) | 25 | -18.3 | 69 25 32.1 148 41 44.3 |
| 74 | Sagwon MAT | vegetated boil (mound) | 26 | -17.2 | 69 25 32.2 148 41 43.2 |
| 75 | Sagwon MAT | interboil moist | 25 | -18.6 | 69 25 32.0 148 41 43.5 |
| 76 | Sagwon MAT | vegetated boil (mound) | 28 | -17.5 | 69 25 32.4 148 41 43.6 |
| 77 | Sagwon MAT | interboil moist | 35 | -16.7 | 69 25 32.5 148 41 43.6 |
| 78 | Sagwon MAT | vegetated boil (mound) | 12 | -22.3 | 69 25 33.2 148 41 43.2 |
| 79 | Sagwon MAT | interboil moist | 30 | -16.4 | 69 25 33.0 148 41 44.9 |

**Table 1. (continued)**

| Relevé | Location | Type | Snow depth (cm) | Soil surface temp. (˚C) | GPS (dd mm ss.s) |
|---|---|---|---|---|---|
| 80 | Sagwon MAT | vegetated boil (mound) | 22 | -18.4 | 69 25 33.1 148 41 51.1 |
| 81 | Sagwon MAT | interboil moist | not found | | 69 25 33.2 148 41 51.2 |
| 82 | Happy Valley | vegetated boil (mound) | 69 | -10.5 | 69 08 48.7 148 50 54.3 |
| 83 | Happy Valley | vegetated boil (mound) | 52 | -10.8 | 69 08 49.9 148 50 53.6 |
| 84 | Happy Valley | interboil moist | 67 | -9.8 | 69 08 49.1 148 50 52.9 |
| 85 | Happy Valley | interboil moist | 65 | -10.2 | 69 08 49.4 148 50 52.4 |
| 86 | Happy Valley | interboil moist | 57 | -10.6 | 69 08 49.8 148 50 53.4 |
| 87 | Happy Valley | interboil moist | 54 | -10.8 | 69 08 49.0 148 50 51.6 |
| 88 | Happy Valley | vegetated boil | 54 | -12.3 | 69 08 48.7 148 51 05.9 |
| 89 | Happy Valley | vegetated boil | 30 | -14.8 | 69 08 48.6 148 51 07.1 |
| 90 | Happy Valley | vegetated boil | 25 | -14.9 | 69 08 48.6 148 51 08.4 |
| 91 | Happy Valley | vegetated boil | 37 | -12.8 | 69 08 48.2 148 51 07.8 |
| 92 | Happy Valley | vegetated boil | 36 | -13.4 | 69 08 47.6 148 51 08.5 |
| 93 | Happy Valley | vegetated boil (mound) | 57 | -11.4 | 69 08 48.9 148 50 53.0 |
| 94 | Happy Valley | vegetated boil (mound) | 49 | -11.8 | 69 08 48.7 148 50 54.0 |
| 95 | Happy Valley | vegetated boil (mound) | 58 | -10.6 | 69 08 50.1 148 50 54.4 |
| 96 | Franklin Bluffs | vegetated boil, moist | 5 | -9.5 | 69 40 29.1 148 4318.4 |
| 97 | Franklin Bluffs | vegetated boil, moist | 17 | -14.8 | 69 40 29.3 148 43 18.0 |
| 98 | West Dock | interboil moist | 14 | -14.6 | 70 22 28.6 148 33 09.1 |
| 99 | West Dock | interboil moist | 13 | -14.2 | 70 22 28.4 148 33 09.9 |
| 100 | West Dock | interboil moist | 23 | -17.4 | 70 22 29.7 148 33 11.1 |
| 101 | West Dock | interboil moist | 24 | -20.4 | 70 22 29.4 148 33 13.2 |
| 102 | West Dock | interboil moist | not found | | 70 22 53.1 148 33 36.7 |
| 103 | West Dock | interboil moist | 12 | -13.1 | 70 22 28.6 148 33 08.2 |
| 104 | Deadhorse | bare frost boils | 33 | -12.9 | 70 09 41.3 148 28 02.5 |
| 105 | Deadhorse | interboil moist | 20 | -10.6 | 70 09 38.2 148 28 09.5 |
| 106 | Deadhorse | bare frost boils | 36 | -13.2 | 70 09 37.0 148 28 07.1 |

Remarks: Relevés on Howe Island not found because they were not marked with stakes. Snow depth and soil surface temperatures were measured next to plot markers with a combination snow depth-soil surface temperature instrument (manufactured by Jon Holmgren) and an Omega Model 865/866 digital thermometer

**Table 2. Detailed depth and density measured on the four sides of the 10 x 10 m Biocomplexity grids**

**a) Location: Howe Island** Observer: Dmitri Sergueev

Data gathered: Average depth of snow on 10x10 m grid = 6.5 cm, 0.23 g/cm³, horizontally sampled at 10 cm depth

**b) Location: West Dock** Date: 12 April 2003

Observers: Corinne Munger Coring equipment: Matthew Sturm's

| Site | Orientation | Snow depth (cm) | Snow volume ($cm^3$) | Snow weight (g) | Snow density ($g/cm^3$) |
|---|---|---|---|---|---|
| **West Dock** | N | 11 | 126.1 | 21 | 0.17 |
| | E | 15 | 172.0 | 22 | 0.13 |
| | S | 21 | 240.7 | 55 | 0.23 |
| | W | 14 | 160.5 | 17 | 0.11 |
| **site average:** | | **15.25** | | | **0.16** |

**c) Location: Deadhorse** Date: 13 April 2003

Observers: Corinne Munger Coring equipment: Matthew Sturm's

| Site | Orientation | Snow depth (cm) | Snow volume ($cm^3$) | Snow weight (g) | Snow density ($g/cm^3$) |
|---|---|---|---|---|---|
| **DH** | N | 45 | 515.9 | 145 | 0.28 |
| | E | 46 | 527.3 | 167 | 0.32 |
| | S | 28 | 321.0 | 133 | 0.41 |
| | W | 51 | 584.7 | 150 | 0.26 |
| **site average:** | | **42.5** | | | **0.32** |

**d) Location: Franklin Bluffs** Date: April 13, 2003

Observers: Corinne Munger Coring equipment: Matthew Sturm's

| Site | Orientation | next to | Snow depth (cm) | Snow volume ($cm^3$) | Snow weight (g) | Snow density($g/cm^3$) |
|---|---|---|---|---|---|---|
| **FBd** | N | K5 | 8 | 91.7 | 21 | 0.23 |
| | E | F11 | 14 | 160.5 | 44 | 0.27 |
| | S | A5 | 21 | 240.7 | 103 | 0.43 |
| | W | F1 | 13 | 149.0 | 27 | 0.18 |
| **site average** | | | **14** | | | **0.28** |

**Table 2.** (continued)
**d) Location: Franklin Bluffs**

| Site | Orientation | next to | Snow depth (cm) | Snow volume ($cm^3$) | Snow weight (g) | Snow density($g/cm^3$) |
|---|---|---|---|---|---|---|
| **FBm** | N | K5 | 24 | 275.1 | 78 | 0.28 |
| | E | F11 | 23 | 263.7 | 187 | 0.71 |
| | S | A5 | 25 | 286.6 | 70 | 0.24 |
| | W | F1 | 21 | 240.7 | 54 | 0.22 |
| **site average** | | | **23.25** | | | **0.37** |
| FBw | N | K5 | 29 | 332.5 | 172 | 0.52 |
| | E | F11 | 26 | 298.1 | 87 | 0.29 |
| | S | A5 | 45 | 515.9 | 198 | 0.38 |
| | W | F1 | 28 | 321.0 | 87 | 0.27 |
| **site average:** | | | **32** | | | **0.37** |

e) **Location: Sagwon** Date: 11 April 2003
Observers: Corinne Munger Coring equipment: Matthew Sturm's

| Site | Orientation | next to | Snow depth (cm) | Snow volume ($cm^3$) | Snow weight (g) | Snow density($g/cm^3$) |
|---|---|---|---|---|---|---|
| **SagMNT1** | N | K5 | 18 | 206.4 | 57 | 0.28 |
| | E | F11 | 39 | 447.1 | 153 | 0.34 |
| | S | A5 | 31 | 355.4 | 72 | 0.20 |
| | W | F1 | 46 | 527.3 | 122 | 0.23 |
| **site average:** | | | **33.5** | | | **0.26** |

| Site | Orientation | next to | Snow depth (cm) | Snow volume ($cm^3$) | Snow weight (g) | Snow density($g/cm^3$) |
|---|---|---|---|---|---|---|
| **SagMNT2** | N | F1 | 35 | 401.2 | 100 | 0.25 |
| **(new)** | E | K5 | 33 | 378.3 | 82 | 0.22 |
| | S | F11 | 20 | 229.3 | 54 | 0.24 |
| | W | A5 | 27 | 309.5 | 225 | 0.73 |
| **site average:** | | | **28.75** | | | **0.36** |

**Table 2.** (continued)

e) **Location: Sagwon (continued)**

| Site | Orientation | next to | Snow depth (cm) | Snow volume ($cm^3$) | Snow weight (g) | Snow density($g/cm^3$) |
|---|---|---|---|---|---|---|
| **Sagwon MAT** | N | F11 | 20 | 229.3 | 116 | 0.51 |
| | E | A5 | 27 | 309.5 | 45 | 0.15 |
| | S | F11 | 49 | 561.7 | 131 | 0.23 |
| | W | K5 | 41 | 470.0 | 82 | 0.17 |
| **site average:** | | | **34.25** | | | **0.26** |

f) **Location: Happy Valley** Date: April 10, 2003

Observers: Anja Kade Coring equipment: Matthew Sturm's

| Site | Orientation | next to | Snow depth (cm) | Snow volume ($cm^3$) | Snow weight (g) | Snow density($g/cm^3$) |
|---|---|---|---|---|---|---|
| **HVd** | N | K5 | 66 | 756.6 | 95 | 0.13 |
| | E | F11 | 58 | 664.9 | 150 | 0.23 |
| | S | A5 | 43 | 493.0 | 146 | 0.30 |
| | W | F1 | 42 | 481.5 | 116 | 0.24 |
| **site average:** | | | **52.25** | | | **0.22** |
| **Site** | **Orientation** | **next to** | **Snow depth (cm)** | **Snow volume ($cm^3$)** | **Snow weight (g)** | **Snow density($g/cm^3$)** |
| **HVm** | N | K5 | 60 | 687.8 | 144 | 0.21 |
| | E | F11 | 64 | 733.7 | 126 | 0.17 |
| | S | A5 | 49 | 561.7 | 116 | 0.21 |
| | W | F1 | 53 | 607.6 | 163 | 0.27 |
| **site average:** | | | **56.5** | | | **0.21** |
| **Site** | **Orientation** | **next to** | **Snow depth (cm)** | **Snow volume ($cm^3$)** | **Snow weight (g)** | **Snow density($g/cm^3$)** |
| **HVw** | N | K5 | 76 | 871.3 | 237 | 0.27 |
| | E | F11 | 44 | 504.4 | 110 | 0.22 |
| | S | A5 | 67 | 768.1 | 145 | 0.19 |
| | W | F1 | 63 | 722.2 | 196 | 0.27 |
| **site average:** | | | **62.5** | | | **0.24** |

Remarks: Density was measured with a Federal snow corer having the cross-sectional area of 11.464 $cm^2$

**Table 3. Depth, snow water equivalent (SWE), and snow density at the Biocomplexity Grids**

| Site | depth (cm) ± s.e. | density ($g/cm^3$) ± s.e. | SWE snow-water equivalent $cm^3$ (density*depth) ± s.e. |
|---|---|---|---|
| HI | 7 | 0.23 | 1.50 |
| WD | 15.3 ± 2.1 | 0.16 ± 0.03 | 2.51 ± 0.77 |
| DH | 42.5 ± 5.0 | 0.32 ± 0.03 | 12.98 ± 0.62 |
| FBd | 14.0 ± 2.7 | 0.28 ± 0.05 | 4.25 ± 1.63 |
| FBm | 23.3 ± 0.9 | 0.37 ± 0.12 | 8.48 ± 2.65 |
| FBw | 32.0 ± 4.4 | 0.37 ± 0.06 | 11.86 ± 2.51 |
| SN1 | 33.5 ± 6.0 | 0.26 ± 0.03 | 8.81 ± 1.94 |
| SN2 | 28.8 ± 3.4 | 0.36 ± 0.12 | 10.05 ± 3.30 |
| SA | 34.3 ± 6.6 | 0.26 ± 0.08 | 8.16 ± 1.67 |
| HVd | 52.3 ± 5.9 | 0.22 ± 0.04 | 11.06 ± 1.14 |
| HVm | 56.5 ± 3.4 | 0.21 ± 0.02 | 11.97 ± 0.90 |
| HVw | 62.5 ± 6.7 | 0.24 ± 0.02 | 15.00 ± 2.44 |

Remarks:
Measurements taken at 4 sides of each grid. Howe Island is from a single data measurement on the north side of the grid.

## Table 4. Snow depth measurements (cm) on the 10 x 10 m Biocomplexity Grids

**Remarks on Table 4**
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** Date: 12 April 2003
Observers: Hilmar Maier, Skip Walker Photo: ~15-28, roll #5
Weather: windy 15-20mph, overcast

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **K** | 8 | 7 | 5 | 5 | 7 | 5 | 8 | 9 | 7 | 6 | 3 | |
| **J** | 6 | 7 | 4 | 4 | 5 | 9 | 4 | 5 | 6 | 5 | 3 | |
| **I** | 1 | 7 | 5 | 1 | 3 | 5 | 5 | 3 | 4 | 3 | 5 | |
| **H** | 6 | 6 | 7 | 5 | 6 | 8 | 6 | 6 | 5 | 4 | 3 | |
| **G** | 7 | 12 | 6 | 8 | 7 | 8 | 10 | 5 | 6 | 8 | 5 | mean = 6.5 |
| **F** | 4 | 12 | 9 | 8 | 7 | 8 | 8 | 6 | 8 | 8 | 7 | SD = 2.3 |
| **E** | 4 | 9 | 7 | 8 | 8 | 8 | 7 | 11 | 6 | 5 | 9 | n = 121 |
| **D** | 5 | 5 | 7 | 5 | 6 | 7 | 8 | 4 | 9 | 8 | 8 | SE = 0.2 |
| **C** | 5 | 11 | 7 | 5 | 10 | 4 | 13 | 3 | 6 | 6 | 8 | |
| **B** | 5 | 7 | 7 | 6 | 8 | 4 | 6 | 7 | 7 | 9 | 13 | |
| **A** | 4 | 6 | 8 | 4 | 6 | 7 | 7 | 7 | 11 | 8 | 10 | |

Remarks:
Thin ice crust (1/4") over 3-8 cm of depth hoar, abundant sastrugi. Bare soil : 1% in grid, 10-20% elsewhere. Air temp :10.2˚C surface temp -13.8˚C. Photo: #30-32. Snow description: hexagonal plates cup-shaped to 5 mm, aggregated in vertical columns beneath 5 mm ice crust.

**Snow depth (cm) in major vegetation types:**

| | | | | | | | | | | | **mean** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **frost boils** | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0.3 |
| **cryptogamic crust** | 8 | 10 | 23 | 0 | 1 | 2 | 6 | 3 | 4 | 2 | 5.9 |
| **troughs** | 40 | 50 | 29 | 28 | 32 | 28 | 35 | 38 | 42 | 32 | 35.4 |

**Table 4. (cont.)**

**b) Location: West Dock** Date: 12 April 2003

Observers: Skip Walker, Hilmar Maier Weather: clear, 30 mph wind, temp ~ 0˚F

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **K** | 7 | 19 | 11 | 13 | 10 | 11 | 11 | 10 | 10 | 8 | 7 | |
| **J** | 11 | 11 | 13 | 15 | 12 | 10 | 13 | 10 | 13 | 11 | 10 | |
| **I** | 14 | 12 | 11 | 8 | 17 | 12 | 12 | 15 | 10 | 11 | 10 | mean = 13.1 |
| **H** | 14 | 13 | 14 | 11 | 9 | 16 | 14 | 10 | 12 | 11 | 13 | SD = 3.5 |
| **G** | 14 | 11 | 15 | 12 | 13 | 10 | 11 | 20 | 10 | 8 | 11 | n = 121 |
| **F** | 13 | 11 | 14 | 13 | 12 | 10 | 11 | 8 | 22 | 12 | 10 | SE = 0.3 |
| **E** | 11 | 11 | 15 | 13 | 15 | 18 | 16 | 11 | 6 | 17 | 8 | |
| **D** | 14 | 13 | 16 | 14 | 15 | 17 | 18 | 13 | 18 | 9 | 21 | |
| **C** | 14 | 18 | 16 | 15 | 15 | 17 | 13 | 12 | 19 | 9 | 7 | |
| **B** | 21 | 17 | 17 | 17 | 19 | 18 | 17 | 10 | 16 | 14 | 6 | |
| **A** | 16 | 18 | 19 | 16 | 19 | 13 | 13 | 11 | 13 | 13 | 8 | |

**c) Location: Deadhorse** Date: 12 April 2003

Observers: Hilmar Maier, Skip Walker Weather: cloudy

Photos: Roll 03-05-29

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **K** | 51 | 49 | 50 | 46 | 37 | 40 | 32 | 44 | 48 | 57 | 47 | |
| **J** | 51 | 44 | 39 | 47 | 47 | 52 | 47 | 43 | 42 | 50 | 52 | |
| **I** | 47 | 39 | 27 | 37 | 46 | 39 | 42 | 53 | 51 | 57 | 37 | mean = 51.25 |
| **H** | 47 | 34 | 47 | 47 | 27 | 36 | 52 | 64 | 57 | 55 | 40 | SD = 10.3 |
| **G** | 31 | 34 | 39 | 39 | 45 | 47 | 65 | 63 | 52 | 51 | 44 | n = 121 |
| **F** | 38 | 52 | 54 | 49 | 58 | 63 | 56 | 61 | 62 | 52 | 41 | SE = 0.9 |
| **E** | 49 | 46 | 53 | 62 | 62 | 56 | 57 | 52 | 52 | 52 | 44 | |
| **D** | 55 | 54 | 60 | 58 | 71 | 57 | 57 | 37 | 46 | 42 | 41 | |
| **C** | 64 | 70 | 60 | 62 | 68 | 71 | 60 | 55 | 54 | 46 | 46 | |
| **B** | 70 | 59 | 57 | 69 | 71 | 66 | 55 | 53 | 57 | 49 | 47 | |
| **A** | 76 | 74 | 74 | 61 | 60 | 47 | 52 | 54 | 49 | 44 | 43 | |

Remarks:

Grid areas may not be typical of surrounding area. Some areas have sedges showing (15-25 cm snow. Large areas such as this are completely covered (35-60 cm snow). Sastrugi area - 58cm - 64 cm. Average appears to be about 40-45 cm.

**Table 4. (cont.)**

**d) Location: Franklin Bluffs, dry** Date: 13 April 2003

Observers: Anja Kade, Corinne Munger Weather: cloudy, slight breeze, -5˚C

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **K** | 15 | 21 | 14 | 5 | 12 | 20 | 12 | 24 | 22 | 15 | 14 | |
| **J** | 25 | 13 | 21 | 16 | 18 | 12 | 20 | 13 | 17 | 12 | 14 | |
| **I** | 25 | 9 | 10 | 25 | 6 | 18 | 14 | 12 | 10 | 5 | 6 | mean = 12.5 |
| **H** | 18 | 11 | 20 | 6 | 14 | 28 | 6 | 17 | 14 | 17 | 21 | SD = 6.3 |
| **G** | 9 | 16 | 17 | 5 | 13 | 8 | 13 | 25 | 23 | 17 | 6 | n = 121 |
| **F** | 6 | 7 | 18 | 6 | 21 | 10 | 7 | 13 | 6 | 17 | 6 | SE = 0.6 |
| **E** | 17 | 10 | 15 | 7 | 19 | 12 | 14 | 15 | 15 | 24 | 22 | |
| **D** | 14 | 5 | 17 | 1 | 11 | 12 | 5 | 2 | 3 | 14 | 14 | |
| **C** | 19 | 18 | 21 | 9 | 11 | 9 | 9 | 5 | 15 | 9 | 11 | |
| **B** | 6 | 8 | 18 | 3 | 12 | 5 | 8 | 16 | 11 | 3 | 9 | |
| **A** | 1 | 11 | 2 | 6 | 9 | 15 | 11 | 15 | 1 | 1 | 7 | |

**e) Location Franklin Bluffs, moist** Date: 13 April 2003

Observers: Anja Kade, Corinne Munger Weather: cloudy, slight breeze, -5˚C

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **K** | 17 | 20 | 25 | 15 | 9 | 22 | 25 | 29 | 16 | 22 | 37 | |
| **J** | 11 | 21 | 15 | 26 | 19 | 18 | 18 | 23 | 26 | 29 | 28 | |
| **I** | 16 | 22 | 19 | 19 | 12 | 34 | 30 | 13 | 24 | 24 | 27 | mean = 21.8 |
| **H** | 30 | 19 | 16 | 7 | 14 | 24 | 21 | 18 | 29 | 21 | 20 | SD = 7.2 |
| **G** | 31 | 20 | 15 | 16 | 20 | 21 | 15 | 26 | 15 | 23 | 31 | n = 121 |
| **F** | 26 | 23 | 27 | 17 | 21 | 27 | 25 | 33 | 19 | 34 | 27 | SE = 0.7 |
| **E** | 21 | 23 | 17 | 29 | 38 | 27 | 26 | 36 | 20 | 26 | 33 | |
| **D** | 9 | 18 | 26 | 33 | 24 | 39 | 34 | 31 | 29 | 38 | 31 | |
| **C** | 10 | 10 | 10 | 25 | 14 | 14 | 22 | 18 | 24 | 28 | 32 | |
| **B** | 21 | 15 | 14 | 19 | 14 | 17 | 8 | 19 | 9 | 17 | 18 | |
| **A** | 24 | 22 | 22 | 21 | 21 | 23 | 9 | 14 | 25 | 12 | 16 | |

**Table 4. (cont.)**

**f) Location: Franklin Bluffs, wet** Date: 13 April 2003

Observers: Anja Kade, Corinne Munger Weather: cloudy, very slight breeze, 5˚C

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **K** | 31 | 26 | 34 | 26 | 18 | 27 | 27 | 21 | 17 | 29 | 27 | |
| **J** | 26 | 22 | 32 | 22 | 25 | 26 | 24 | 20 | 24 | 32 | 36 | |
| **I** | 30 | 26 | 18 | 18 | 24 | 28 | 29 | 28 | 32 | 40 | 44 | mean = 30.9 |
| **H** | 32 | 19 | 13 | 13 | 19 | 28 | 33 | 36 | 36 | 48 | 39 | SD = 10.1 |
| **G** | 28 | 16 | 13 | 16 | 26 | 33 | 38 | 40 | 25 | 47 | 49 | n = 121 |
| **F** | 31 | 30 | 20 | 17 | 32 | 39 | 41 | 41 | 26 | 45 | 44 | SE = 0.9 |
| **E** | 35 | 37 | 36 | 36 | 38 | 42 | 49 | 50 | 42 | 43 | 42 | |
| **D** | 39 | 42 | 40 | 42 | 44 | 47 | 36 | 48 | 46 | 47 | 47 | |
| **C** | 35 | 22 | 43 | 44 | 30 | 47 | 41 | 25 | 27 | 23 | 22 | |
| **B** | 35 | 23 | 17 | 13 | 22 | 25 | 38 | 19 | 24 | 21 | 24 | |
| **A** | 14 | 20 | 25 | 27 | 24 | 23 | 15 | 26 | 26 | 45 | 45 | |

Remarks:
A1 was the only labeled corner; we assumed that K1 was the corner north of A1, which means the grid corresponds to the data sheet orientation. Snow is very hard, especially on west side of grid.

g) **Location: Sagwon grid: MNT-1 (old)** Date: 11 April 2003

Observers: Skip Walker, Hilmar Maier Weather: calm, clear, -25˚C

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **K** | 26 | 26 | 24 | 29 | 23 | 28 | 22 | 33 | 18 | 18 | 25 | |
| **J** | 37 | 28 | 39 | 23 | 23 | 27 | 28 | 23 | 25 | 24 | 33 | |
| **I** | 29 | 33 | 35 | 33 | 32 | 30 | 38 | 23 | 27 | 23 | 34 | mean = 32.5 |
| **H** | 29 | 33 | 30 | 44 | 24 | 26 | 27 | 30 | 24 | 27 | 19 | SD = 6.5 |
| **G** | 32 | 31 | 38 | 37 | 32 | 42 | 25 | 37 | 26 | 40 | 27 | n = 121 |
| **F** | 26 | 36 | 49 | 28 | 44 | 30 | 44 | 40 | 28 | 33 | 35 | SE = 0.6 |
| **E** | 38 | 46 | 32 | 32 | 31 | 32 | 40 | 38 | 33 | 32 | 38 | |
| **D** | 33 | 35 | 39 | 31 | 40 | 34 | 35 | 35 | 23 | 41 | 33 | |
| **C** | 38 | 28 | 35 | 36 | 30 | 35 | 40 | 42 | 37 | 39 | 26 | |
| **B** | 29 | 36 | 45 | 40 | 42 | 37 | 43 | 39 | 36 | 33 | 25 | |
| **A** | 31 | 38 | 32 | 30 | 40 | 35 | 43 | 29 | 32 | 34 | 39 | |

Remarks:
Snow is harder and shallower. More sastrugi than at Sagwon MAT. Photo: none.

**Table 4. (cont.)**

**h) Location: Sagwon grid: MNT 2 (new)** Date: 11 April 2003

Observers: Skip Walker, Hilmar Maier Weather: calm, clear, -25˚ C

**# = drift**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **K** | 33 | 36 | **43** | **41** | **46** | 25 | 24 | 39 | 31 | 30 | 33 |
| **J** | 41 | 42 | 30 | 38 | 27 | 25 | 33 | **26** | 33 | 27 | 23 |
| **I** | 40 | 38 | 25 | 35 | **38** | **37** | 33 | **37** | 39 | 23 | 27 |
| **H** | 27 | 27 | 36 | 32 | **35** | 29 | **36** | **41** | 32 | 27 | 20 |
| **G** | 27 | 39 | 38 | 26 | 28 | **38** | 27 | **36** | 42 | 28 | 20 |
| **F** | 28 | 37 | 38 | 30 | 37 | **28** | **32** | **36** | 24 | 23 | 21 |
| **E** | 31 | 33 | 34 | 36 | 33 | 33 | **32** | **40** | 31 | 23 | 17 |
| **D** | 29 | 29 | 38 | 35 | **31** | **44** | 28 | 37 | 27 | 23 | 31 |
| **C** | 36 | 39 | 27 | 33 | **32** | **38** | 23 | 23 | 23 | 31 | 35 |
| **B** | 27 | 32 | **30** | 40 | **42** | **36** | 30 | 28 | 23 | 21 | 24 |
| **A** | 32 | 26 | **31** | 33 | **41** | **36** | 39 | 25 | 27 | 42 | 27 |

| | |
|---|---|
| mean = | 31.8 |
| SD = | 6.2 |
| n = | 121 |
| SE = | 0.6 |

Remarks:
Grid is oriented incorrectly, N is to left (not up; Photo: none.

**i) Location: Sagwon MAT** Weather: calm, clear, -28˚C

Observers: Skip Walker, Corinne Munger, Hilmar Maier

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **K** | 32 | 35 | 28 | 35 | 10 | 30 | 42 | 43 | 50 | 52 | 41 |
| **J** | 31 | 27 | 50 | 48 | 43 | 40 | 38 | 46 | 37 | 37 | 43 |
| **I** | 40 | 25 | 30 | 36 | 35 | 33 | 35 | 48 | 40 | 43 | 25 |
| **H** | 31 | 25 | 31 | 43 | 46 | 44 | 32 | 46 | 35 | 35 | 40 |
| **G** | 41 | 37 | 44 | 46 | 44 | 28 | 35 | 28 | 36 | 35 | 37 |
| **F** | 25 | 37 | 16 | 28 | 39 | 44 | 46 | 29 | 45 | 45 | 32 |
| **E** | 26 | 31 | 36 | 26 | 39 | 38 | 37 | 25 | 43 | 44 | 43 |
| **D** | 35 | 29 | 35 | 25 | 42 | 42 | 52 | 35 | 53 | 43 | 37 |
| **C** | 30 | 28 | 36 | 35 | 31 | 48 | 37 | 30 | 44 | 42 | 39 |
| **B** | 33 | 32 | 48 | 34 | 44 | 50 | 46 | 46 | 50 | 45 | 44 |
| **A** | 33 | 20 | 20 | 43 | 44 | 48 | 50 | 46 | 43 | 45 | 38 |

| | |
|---|---|
| mean = | 37.6 |
| SD = | 8.2 |
| n = | 121 |
| SE = | 0.7 |

**Table 4. (cont.)**

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

Date: 10 April 2003
Weather: clear, slight breeze, -14˚C

Observers: Corinne Munger, Skip Walker, Hilmar Maier

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **K** | 36 | 29 | 47 | 44 | 38 | 42 | 47 | 45 | 46 | 38 | 43 | |
| **J** | 52 | 51 | 54 | 40 | 44 | 60 | 48 | 54 | 52 | 47 | 55 | |
| **I** | 31 | 40 | 49 | 34 | 43 | 37 | 42 | 43 | 30 | 42 | 43 | mean = 45.8 |
| **H** | 35 | 39 | 45 | 46 | 51 | 34 | 35 | 38 | 53 | 58 | 44 | SD = 7.7 |
| **G** | 29 | 43 | 31 | 44 | 49 | 33 | 36 | 34 | 42 | 35 | 47 | n = 121 |
| **F** | 33 | 45 | 42 | 43 | 47 | 55 | 45 | 45 | 50 | 48 | 56 | SE = 0.7 |
| **E** | 45 | 35 | 45 | 59 | 41 | 48 | 49 | 53 | 50 | 49 | 55 | |
| **D** | 51 | 40 | 42 | 50 | 56 | 45 | 46 | 52 | 55 | 39 | 54 | |
| **C** | 53 | 39 | 57 | 47 | 38 | 57 | 54 | 53 | 45 | 51 | 54 | |
| **B** | 45 | 47 | 50 | 48 | 40 | 63 | 45 | 43 | 51 | 52 | 56 | |
| **A** | 47 | 49 | 45 | 49 | 46 | 35 | 41 | 53 | 52 | 57 | 70 | |

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

Date: 10 April 2003
Weather: clear, calm, -14˚C

Observers: Skip Walker, Hilmar Maier, Corinne Munger

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **K** | 76 | 57 | 76 | 59 | 68 | 56 | 73 | 64 | 62 | 57 | 56 | |
| **J** | 79 | 78 | 56 | 58 | 67 | 68 | 70 | 57 | 54 | 66 | 72 | |
| **I** | 66 | 65 | 56 | 61 | 58 | 63 | 44 | 61 | 69 | 61 | 65 | mean = 60.5 |
| **H** | 65 | 58 | 52 | 66 | 58 | 68 | 63 | 61 | 48 | 53 | 57 | SD = 6.8 |
| **G** | 58 | 55 | 68 | 62 | 58 | 53 | 56 | 68 | 65 | 64 | 71 | n = 121 |
| **F** | 41 | 60 | 59 | 55 | 64 | 58 | 62 | 53 | 63 | 49 | 63 | SE = 0.6 |
| **E** | 71 | 62 | 62 | 55 | 64 | 62 | 65 | 61 | 62 | 55 | 67 | |
| **D** | 65 | 54 | 67 | 49 | 60 | 57 | 52 | 54 | 63 | 62 | 56 | |
| **C** | 71 | 58 | 59 | 64 | 52 | 61 | 61 | 67 | 56 | 67 | 70 | |
| **B** | 54 | 60 | 45 | 58 | 54 | 57 | 57 | 60 | 53 | 49 | 55 | |
| **A** | 63 | 65 | 65 | 64 | 60 | 59 | 53 | 53 | 58 | 64 | 53 | |

**Table 4. (cont.)**

**l) Location: Happy Valley, grid: Toe slope (wet)** Date: 10 April 2003

Weather: sunny, clear, calm, -14 ˚C

Observers: Skip Walker, Hilmar Maier, Corinne Munger

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **K** | 71 | 83 | 72 | 63 | 73 | 63 | 56 | 60 | 64 | 60 | 66 | | |
| **J** | 50 | 73 | 77 | 72 | 68 | 64 | 63 | 60 | 53 | 58 | 69 | | |
| **I** | 51 | 68 | 75 | 66 | 56 | 71 | 66 | 47 | 55 | 61 | 52 | mean = | 64.1 |
| **H** | 67 | 70 | 69 | 55 | 68 | 68 | 67 | 57 | 64 | 48 | 66 | SD = | 7.2 |
| **G** | 70 | 64 | 61 | 63 | 63 | 72 | 56 | 67 | 60 | 49 | 50 | n = | 121 |
| **F** | 76 | 76 | 64 | 71 | 68 | 65 | 74 | 63 | 62 | 58 | 60 | SE = | 0.7 |
| **E** | 63 | 58 | 70 | 71 | 70 | 72 | 71 | 67 | 66 | 66 | 68 | | |
| **D** | 69 | 47 | 49 | 66 | 55 | 60 | 68 | 64 | 63 | 66 | 59 | | |
| **C** | 64 | 72 | 60 | 61 | 70 | 68 | 66 | 61 | 69 | 70 | 66 | | |
| **B** | 67 | 68 | 77 | 68 | 62 | 63 | 60 | 63 | 67 | 47 | 62 | | |
| **A** | 54 | 70 | 75 | 67 | 70 | 61 | 55 | 55 | 59 | 66 | 67 | | |

# Figures

**Figure 1.**

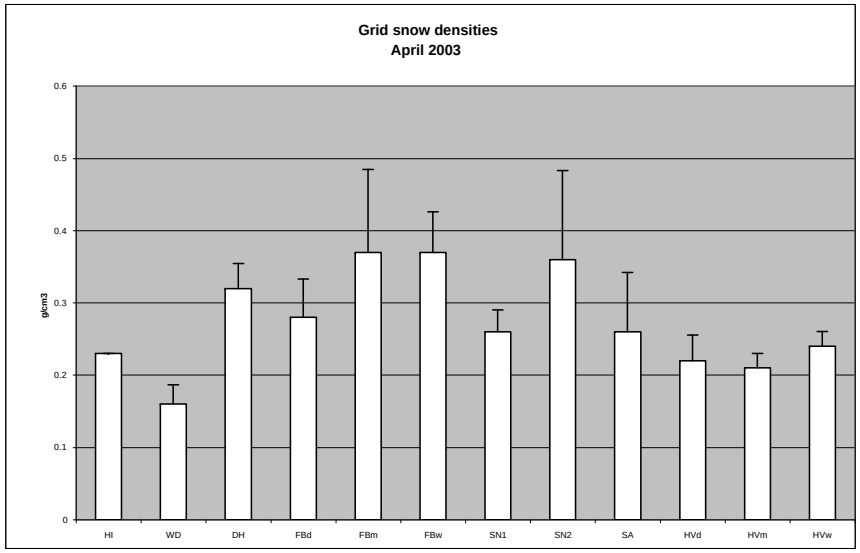



**Figure 2.**

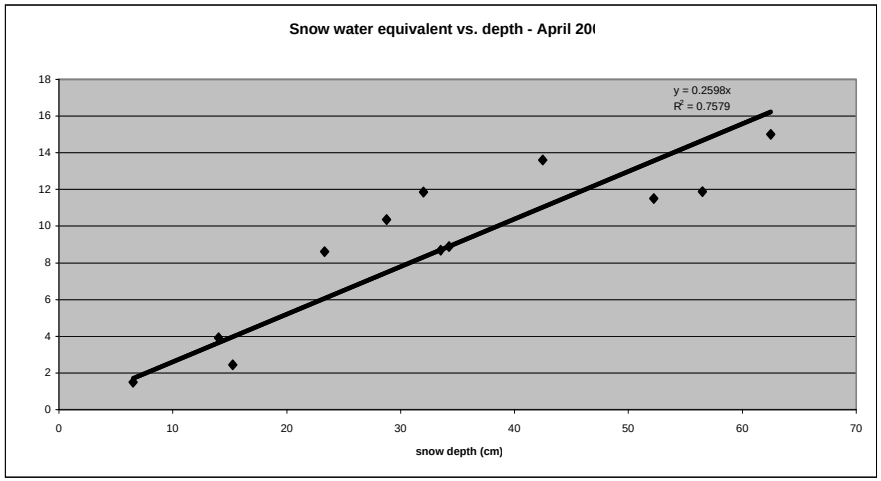



**Figure 3.**

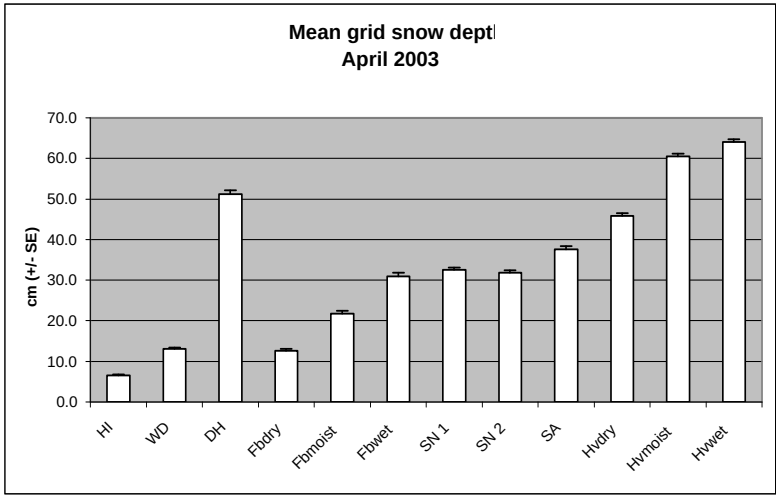



**Figure 4.**

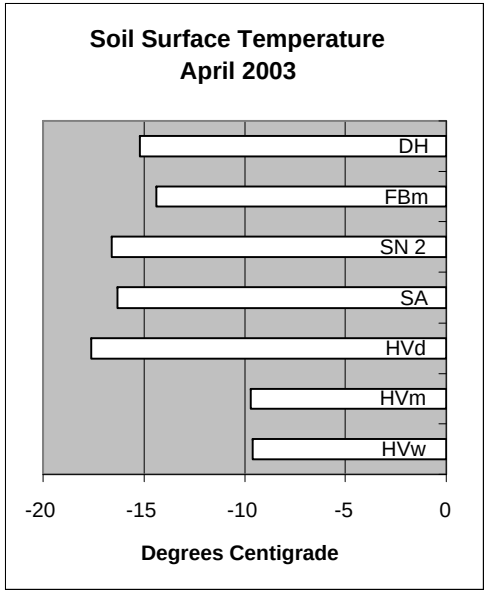
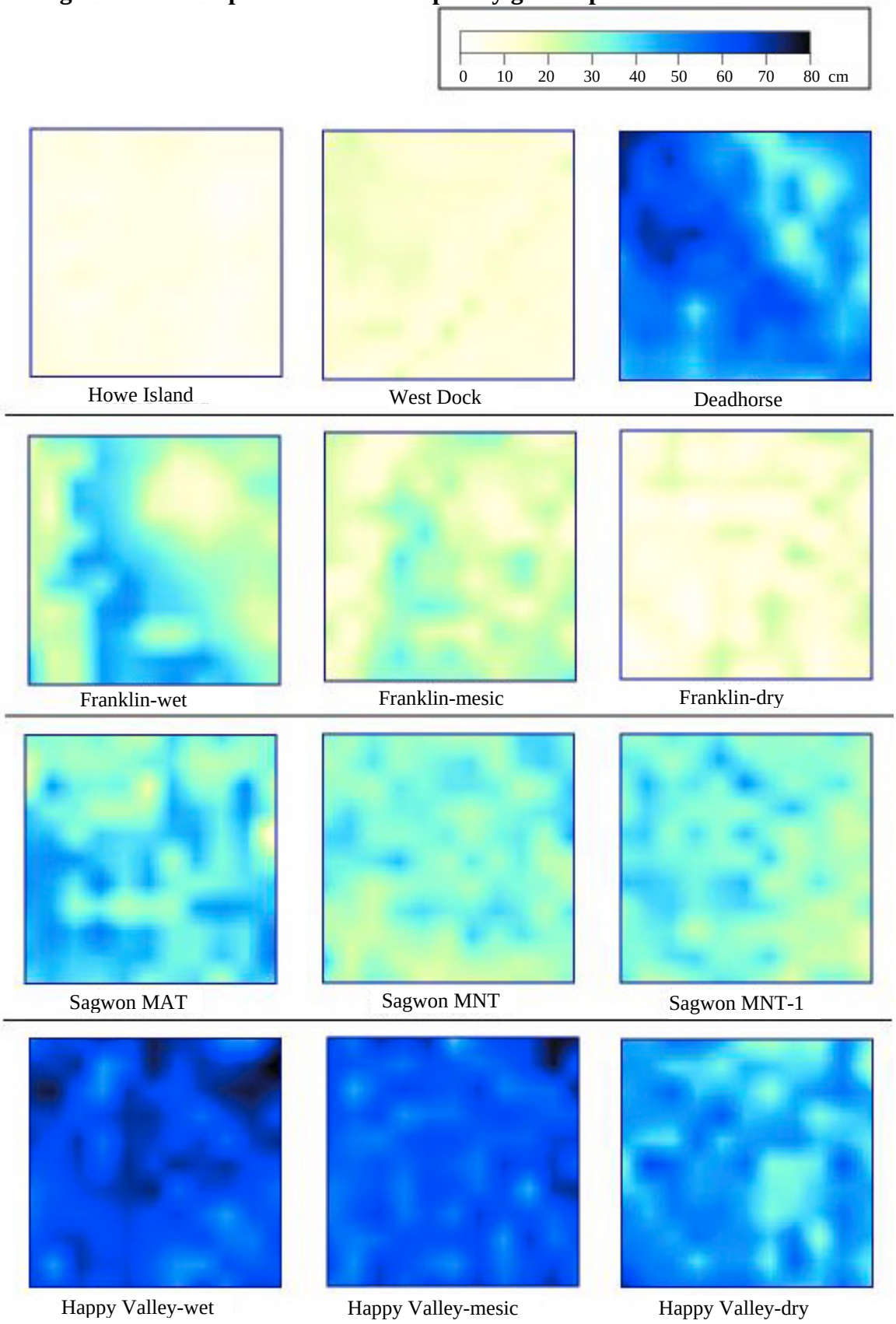


**Figure 5. Snow depths on the Biocomplexity grids April 2003**



# Appendices

## Appendix A. Photographs

Photo 1.
Dmitri Sergueev downloading data from climate station at Howe Island.

Photo 2.
Snow pit showing depth hoar beneath ice lens at Howe Island with temperature meter.

Photo 3.
Snow pit at Deadhorse.

Photo 4.
Dmitri Sergueev and Skip Walker collecting snow for snow density measurement, Deadhorse site.

Photo 1.

Photo 2.


Photo 3.


Photo 4.

**Appendix A**. **(cont. )**

Photo 5.
Skip Walker and REU student Corinne Munger setting up transect to measure snow depth.

Photo 6.
Dmitri Sergueev digging snow pit, with Corinne Munger and Skip Walker standing by.

Photo 7.
Snow pit at, Happy Valley, mesic site.

Photo 8.
Caribou feeding on hilltop south of Pump Station 3; near Dalton Highway milepost 295. Most south-facing hill-slopes with relatively shallow snow in this area had extensive evidence of caribou feeding on tundra beneath the snow.

Photo 5.

Photo 6.

Photo 7.

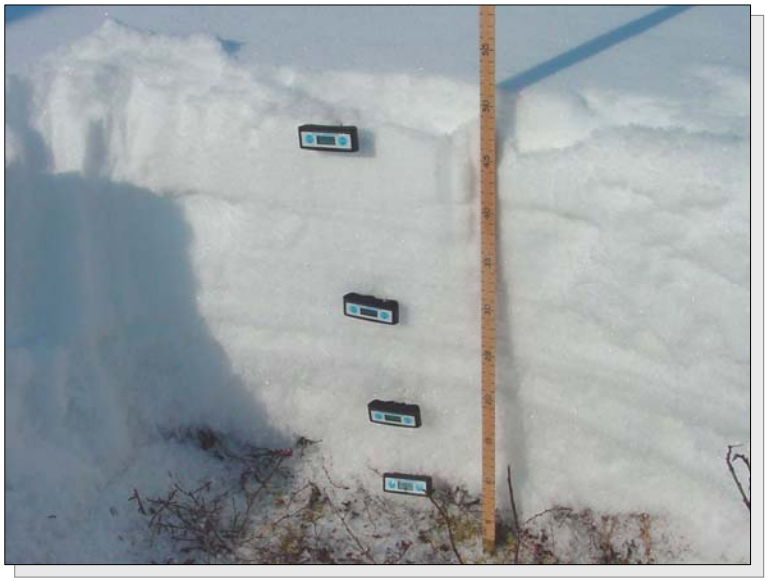


Photo 8.

**Appendix B.**

## SNOW DENSITY

Location: _____ Grid: _____

Observers: _____ Date: _____

Coring equipment: _____ Corer cross-section: _____

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

**Appendix C.**

## 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:

**Appendix D.**

## SNOW PROFILE

Location: _____ Grid: _____

Observers: _____ Date & Time: _____

Sky conditions: _____ Air Temp (°C): _____

| SNOW SURFACE (Circle one) | | | |
|---|---|---|---|
| Smooth | Rippled | Pitted | Gullied |

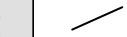
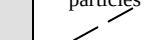
| SURFACE ROUGHNESS (circle one) | | | | |
|---|---|---|---|---|
| Smooth | Wavy | Concave furrows | Convex furrows | Random furrows |
| Average depth of surface irregularities: | | | | |
| Average wavelength (distance between ridges): | | | | |
| Compass direction of ridges: | | | | |

Total snow depth (cm): _____

| Layer | Thickness (cm) | Grain Shape (see crystal classification table) | Grain Size (mm) | Density (g/cm3) | Temp ( °C) | Hardness Index (see table) | Remarks |
|---|---|---|---|---|---|---|---|
| Top 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |
| 5 | | | | | | | |
| 6 | | | | | | | |
| 7 | | | | | | | |
| 8 | | | | | | | |
| 9 | | | | | | | |
| 10 | | | | | | | |

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

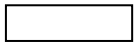
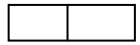
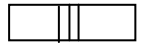
**a)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **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, firn-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 |

**b) Hardness of deposited snow (Colbeck et al. 1992)**

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

**c) Liquid water content (Colbeck et al. 1992)**

| *Term* | *Remarks* | *Approximate Range* | *Symbol* |
|---|---|---|---|
| **Dry** | Dry snow can occur at any temperature up to $0^{o}$C. Disaggregated snow grains have little tendency to adhere to each other when pressed together, as in making a snowball. | 0% |  |
| **Moist** | T = $0^{o}$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 = $0^{o}$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 = $0^{o}$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 = $0^{o}$C. Snow is flooded with water and contains relatively small amounts of air. | > 15% |  |