Snow Survey Data for the Sagavanirktok River / Bullen Point Hydrology Study: Spring 2006

Snow survey sampling on Coastal Plain, M. Lilly

Water and Environmental Research Center

by

Douglas Kane, Sveta Berezovskaya, Ken Irving, Robert Busey,

Molly Chambers, Amanda Blackburn, and Michael Lilly

July 2006

Sagavanirktok River/Bullen Point Hydrology Project

Report No. INE/WERC 06.03

Water and Environmental Research Center

Snow Survey Data for the Sagavanirktok River /Bullen Point Hydrology Study: Spring 2006

by

Douglas Kane[1], Sveta Berezovskaya[1], Ken Irving[1], Robert Busey[1], Molly Chambers[1], Amanda Blackburn[2], Michael Lilly[2]

A report on research sponsored by the

Alaska Department of Transportation and Public Facilities

July 2006

Sagavanirktok River/Bullen Point Hydrology Project

Report Number INE/WERC 06.03

[1]University of Alaska Fairbanks, Water and Environmental Research Center
[2]Geo-Watersheds Scientific, Fairbanks, Alaska

Recommended Citation:

Kane, D.L., Berezovskaya, S., Irving, K., Busey, R., Chambers, M., Blackburn, A.J., and Lilly, M.R., 2006. Snow survey data for the Sagavanirktok River / Bullen Point Hydrology Study: Spring 2006. July 2006, University of Alaska Fairbanks, Water and Environmental Research Center, Report INE/WERC 06-03, Fairbanks, Alaska, 10 pp.

Fairbanks, Alaska
July 2006

For additional information write to:

Publications,
Water and Environmental Research Center
University of Alaska Fairbanks
Fairbanks, Alaska 99775
www.uaf.edu/water/

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the accuracy of the data presented herein. This research was funded by the Alaska Department of Transportation and Public Facilities (AKDOT&PF). The contents of the report do not necessarily reflect the views of policies of the AKDOT&PF or any local sponsor. This work does not constitute a standard, specification, or regulation.

The use of trade and firm names in this document is for the purpose of identification only and does not imply endorsement by the University of Alaska Fairbanks, Alaska Department of Transportation and Public Facilities, or other project sponsors.

UNITS, CONVERSION FACTORS, WATER QUALITY UNITS, VERTICAL AND HORIZONTAL DATUM, ABBREVIATIONS AND SYMBOLS

Conversion Factors

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (mm)
mile (mi)	1.609	kilometer (km)
	Area	
Acre	43559.826	square feet (ft^2)
Acre	0.407	hectare (ha)
square foot (ft^2)	2.590	square mile (mi^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	3785	milliliter (mL)
cubic foot (ft^3)	23.317	liter (L)
Acre-ft	1233	cubic meter (m^3)
	Velocity and Discharge	
foot per day (ft/d)	0.3048	meter per day (m/d)
Square foot per day (ft^2/d)	.0929	square meter per day (m^2/d)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/sec)
	Hydraulic Conductivity	
foot per day (ft/d)	0.3048	meter per day (m/d)
foot per day (ft/d)	0.00035	centimeter per second (cm/sec)
meter per day (m/d)	0.00115	centimeter per second (cm/sec)
	Hydraulic Gradient	
foot per foot (ft/ft)	5280	foot per mile (ft/mi)
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
	Pressure	
pound per square inch (lb/in^2)	6.895	kilopascal (kPa)

Units

For the purposes of this report, both English and Metric (SI) units were employed. The choice of "primary" units employed depended on common reporting standards for a particular property or parameter measured. Whenever possible, the approximate value in the "secondary" units was also provided in parentheses. Thus, for instance, stream flow was reported in cubic feet per second (cfs) followed by the approximate value in cubic meters per second (m^3/s) in parentheses.

Physical Units:

Temperature:

Water and air temperature is given in degrees Celsius (°C) and in degrees Fahrenheit (°F).

Degrees Celsius can be converted to degrees Fahrenheit by use of the following equation:

°F = 1.8(°C) + 32

Millivolt (mV):

A unit of electromotive force equal to one thousandth of a volt.

Vertical Datum:

In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929), a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called *Sea Level Datum of 1929*.

Horizontal Datum:

The horizontal datum for all locations in this report is the North American Datum of 1983.

Abbreviations, Acronyms, and Symbols

AC	Actual conductivity
ADOT&PF	Alaska Department of Transportation and Public Facilities
ASTM	American Society for Testing and Materials
atm	atmospheres
C	Celsius
DO	Dissolved oxygen
DVM	digital voltage multi-meter
e-tape	electric tape
F	Fahrenheit (^{o}F).
ft	feet
GWS	Geo-Watersheds Scientific
GWSI	USGS Ground-Water Site Inventory
km^2	square kilometers
kPa	kilopascal
lb/in^2	pounds per square inch
m	meters
mg/L	Milligrams per liter
µg/L	micrograms per liter
mi^2	square miles
mm	millimeters
µS/cm	microsiemens per centimeter
mV	Millivolt
NGVD	National Geodetic Vertical Datum
NWIS	National Water Information System
ORP	oxygen-reduction potential
ppm	parts per million
QA	quality assurance
QC	quality control
UAF	University of Alaska Fairbanks
USACE	U.S. Army Corps of Engineers, Alaska District
USGS	U.S. Geological Survey
WERC	Water and Environmental Research Center
WWW	World Wide Web
YSI	Yellow Springs Instruments

ACKNOWLEDGEMENTS

This project was funded by grant ADN #2562122, Alaska Department of Transportation and Public Facilities. Field coordination was provided by BP Exploration (Alaska) Inc. Alaska and the Department of Natural Resources provided background data for lakes in the study area.

Snow Survey Data for the Sagavanirktok River / Bullen Point Hydrology Study: Spring 2006

INTRODUCTION

Snow on the Arctic Slope of Alaska lasts up to nine months a year. Water contained in snowpack ensures that snowmelt is a major hydrological event each year. Peak discharge resulting from snowmelt is the highest for many rivers on the North Slope, particularly for the largest basins like the Colville, Sagavanirktok and Kuparuk Rivers. Rivers flowing into the Beaufort Sea drain a large area that extends from the Brooks Range through the Northern Foothills and across the Coastal Plain before discharging into the Arctic Ocean. The data on water content of snowpack at the end-of-winter have been collected in the basins of the Central Alaskan Arctic. Snow depth, snow water equivalent (SWE) and snow density have been measured at numerous sites from the Continental Divide (south) to the Arctic Ocean (north) and from the Canning River (east) to the eastern boundary of the Kuparuk River basin (Figure 1, Tables 1, 2, 3).

SAMPLING METHOD

The snowpack water equivalent (SWE) is estimated using double sampling method. Double sampling refers to the measurement of the snowpack by measuring the depth at a number of points and measuring the snow water equivalent (plus the depth) at a smaller number of points.

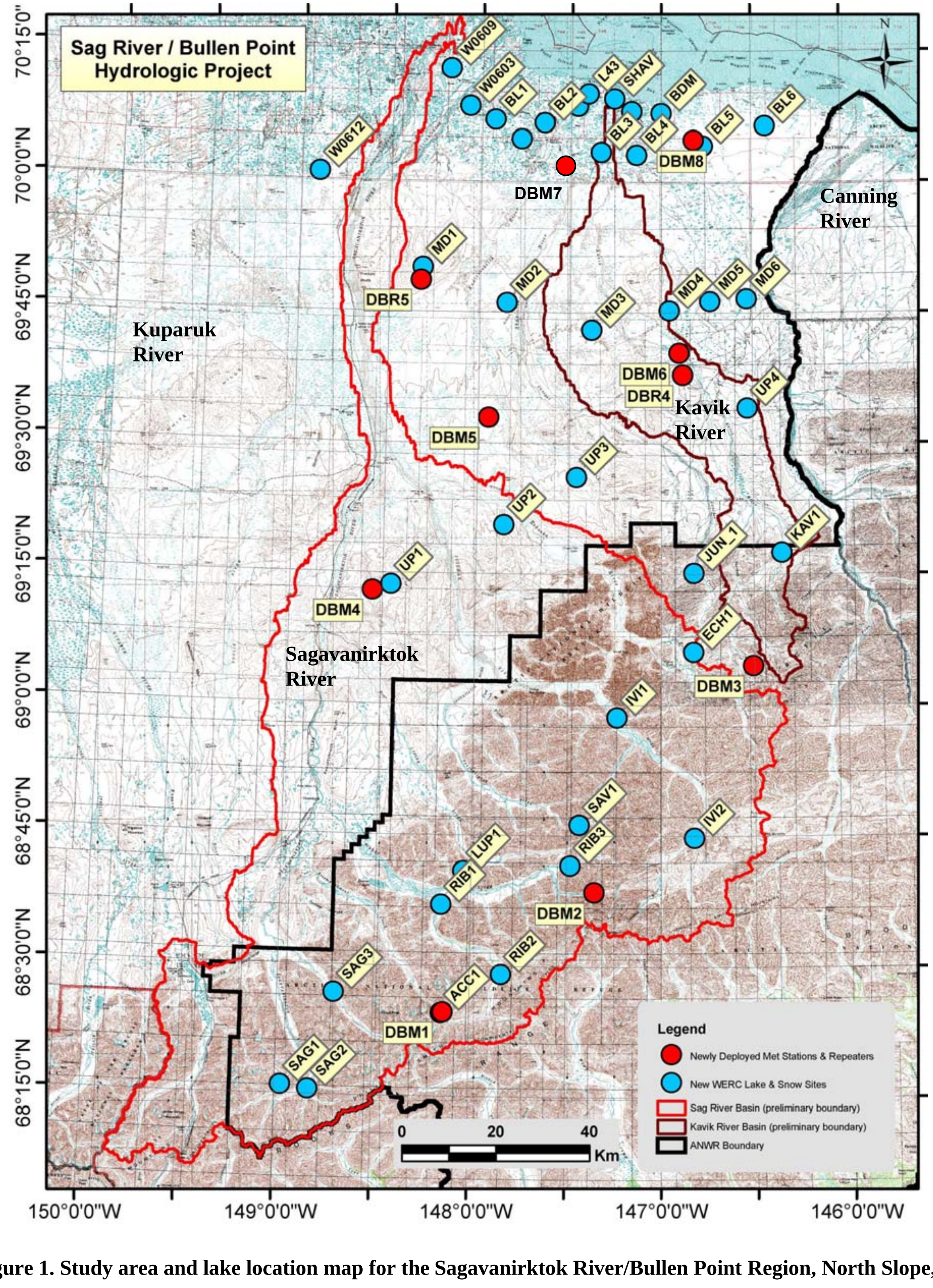

Figure 1. Study area and lake location map for the Sagavanirktok River/Bullen Point Region, North Slope, Alaska, with snow survey sites and meteorological stations.

The approach we use is to measure the snow depth at 50 points along an L-shaped transect with measurements spaced approximately every meter. Twenty-five depth measurements are made on each leg of the L; this strategy is used to account for the presence of snowdrifts in the area of measurement. The directions of measurement are chosen randomly. Five SWE measurements (and accompanying five depths) are taken at each site; from these measurements the density (mass/volume) of the snowpack is determined. Then using this density, with the 50 depth measurements, a new average estimate of the SWE is obtained. This combination of measurements yields an optimal estimate of the average snowpack water equivalent having lower time cost and lower variance, over a larger area, than is possible by measuring just five SWE values (Rovansek et al, 1993).

Snow depth is measured with a T-shaped snow probe. Snow density is sampled with the Adirondack Fiberglass snow sampler (cross-sectional area is 35.7 cm^2) (Woo, 1997). To obtain site average SWE, mean density (from 5 measurements) is multiplied by mean snow depth (50 measurements). Averages of snow depth and SWE measurements taken at each site are listed in Tables 4, 5, 6.

Table 1. Coordinates of mountain snow survey sites in the Sagavanirktok / Bullen Point area established in 2006.

№	ID	ELEV	LAT	LON
		m	*NAD83*	*NAD83*
1	ACC1	1391	68.4102	-148.145
2	RIB1	609	68.6174	-148.153
3	RIB2	800	68.4848	-147.836
4	RIB3	918	68.6931	-147.478
5	SAG1	730	68.2667	-148.967
6	SAG2	868	68.2597	-148.826
7	SAG3	830	68.4462	-148.704
8	SAV1	955	68.7705	-147.432
9	ECH1	868	69.1022	-146.825
10	IVI1	521	68.9767	-147.234
11	IVI2	810	68.7464	-146.823
12	JUN_1	615	69.2526	-146.823
13	KAV1	733	69.2920	-146.348
14	LUP1	747	68.6817	-148.041

Table 2. Coordinates of foothills snow survey sites in the Sagavanirktok / Bullen Point area established in 2006.

№	ID	ELEV	LAT	LON
		m	*NAD83*	*NAD83*
1	MD1	220	69.8350	-148.317
2	MD2	334	69.7688	-147.849
3	MD3	319	69.7170	-147.380
4	MD6	170	69.7772	-146.530
5	UP1	194	69.2276	-148.454
6	UP2	318	69.3439	-147.850
7	UP3	393	69.4356	-147.460
8	UP4	350	69.5689	-146.530

Table 3. Coordinates of coastal plain snow survey sites in the Sagavanirktok / Bullen Point area established in 2006.

№	ID	ELEV	LAT	LON
		m	*NAD83*	*NAD83*
1	MD4	113	69.7544	-146.954
2	MD5	130	69.7721	-146.731
3	WH1	47	70.0149	-148.903
4	WH2	7	70.2148	-148.177
5	WH3	8	70.1443	-147.463
6	WH4	35	70.0814	-147.777
7	BL1	10	70.1184	-147.925
8	BL2	7	70.1126	-147.649
9	BL3	43	70.0516	-147.137
10	BL4	62	70.0566	-147.333
11	BL5	32	70.0689	-146.769
12	BL6	29	70.1073	-146.421
13	L12	4	70.1342	-147.164
14	L15	11	70.1438	-148.068
15	L43	5	70.1681	-147.404
16	L43-Lake	5	70.1645	-147.399
17	SHAV	5	70.1586	-147.259
18	BDM	4	70.1310	-147.000

Table 4. Results of snow survey 2006 for mountain sites: snow depth, snow density and snow water equivalent.

№	ID	DATE	SWE		SNOW DEPTH		SNOW DENSITY	
			cm	*in*	*cm*	*in*	*kg/m3*	*slug/ft3*
1	ACC1	4/27/06	6.0	2.3	35.0	13.8	170	0.330
2	RIB1	4/27/06	6.0	2.3	29.8	11.7	200	0.388
3	RIB2	4/27/06	4.0	1.6	28.3	11.1	140	0.272
4	RIB3	4/27/06	6.7	2.7	39.7	15.6	170	0.330
5	SAG1	4/27/06	-	-	3.6	1.4	-	-
6	SAG2	4/27/06	10.6	4.2	52.9	20.8	200	0.388
7	SAG3	4/27/06	7.3	2.9	31.8	12.5	230	0.446
8	SAV1	4/28/06	10.1	4.0	42.2	16.6	240	0.466
9	ECH1	4/28/06	11.4	4.5	59.8	23.5	190	0.369
10	IVI1	4/28/06	5.1	2.0	25.6	10.1	200	0.388
11	IVI2	4/28/06	7.5	3.0	39.5	15.6	190	0.369
12	JUN_1	4/28/06	8.8	3.5	49.1	19.3	180	0.349
13	KAV1	4/28/06	2.1	0.8	11.2	4.4	190	0.369
14	LUP1	4/27/06	8.7	3.4	39.5	15.6	220	0.427
Average			7.3	2.9	34.9	13.7	194	0.376

Table 5. Results of snow survey 2006 for foothills sites: snow depth, snow density and snow water equivalent.

№	ID	DATE	SWE		SNOW DEPTH		SNOW DENSITY	
			cm	*in*	*cm*	*in*	*kg/m3*	*slug/ft3*
1	MD1	5/3/06	11.8	4.6	33.6	13.2	350	0.679
2	MD2	5/3/06	8.7	3.4	36.1	14.2	240	0.466
3	MD3	5/3/06	10.6	4.2	50.4	19.8	210	0.407
4	MD6	5/3/06	5.1	2.0	13.4	5.3	380	0.737
5	UP1	4/29/06	4.8	1.9	24.0	9.4	200	0.388
6	UP2	5/3/06	7.1	2.8	32.1	12.6	220	0.427
7	UP3	5/3/06	6.6	2.6	36.8	14.5	180	0.349
8	UP4	5/3/06	5.8	2.3	25.3	10.0	230	0.446
Average			7.6	3.0	31.5	12.4	251	0.488

Table 6. Results of snow survey 2006 for coastal plain sites: snow depth, snow density and snow water equivalent.

№	ID	DATE	SWE		SNOW DEPTH		SNOW DENSITY	
			cm	*in*	*cm*	*in*	*kg/m3*	*slug/ft3*
1	MD4	5/3/06	5.8	2.3	29.0	11.4	200	0.388
2	MD5	5/3/06	6.6	2.6	25.4	10.0	260	0.504
3	WH1	5/3/06	9.0	3.5	30.9	12.2	290	0.563
4	WH2	5/2/06	13.9	5.5	38.6	15.2	360	0.699
5	WH3	5/2/06	11.3	4.4	38.8	15.3	290	0.563
6	WH4	5/2/06	10.5	4.1	42.0	16.5	250	0.485
7	BL1	5/2/06	12.3	4.9	53.6	21.1	230	0.446
8	BL2	5/2/06	9.4	3.7	34.9	13.7	270	0.524
9	BL3	5/3/06	9.4	3.7	36.0	14.2	260	0.504
10	BL4	5/3/06	11.8	4.7	43.8	17.2	270	0.524
11	BL5	5/3/06	14.1	5.5	48.5	19.1	290	0.563
12	BL6	4/30/06	6.8	2.7	23.5	9.3	290	0.563
13	L12	4/30/06	11.1	4.4	30.9	12.2	360	0.699
14	L15	4/30/06	12.2	4.8	34.8	13.7	350	0.679
15	L43	4/30/06	6.2	2.4	26.3	10.4	240	0.466
16	L43-Lake	4/30/06	6.9	2.7	23.7	9.3	290	0.563
17	SHAV	5/3/06	9.2	3.6	35.5	14.0	260	0.504
18	BDM	4/30/06	3.2	1.2	15.1	5.9	210	0.407
Average			8.7	3.4	33.1	13.0	265	0.514

SPATIAL DISTRIBUTION OF SNOW SURVEY SITES

Snow survey sites are chosen to represent snow characteristics over a wide range of vegetation and terrain conditions within the domain. The total elevation range within the area bounded by the Sagavanirktok River on the west and the Canning River on the east is from sea level to 8025 ft (0 to 2446 m). Snow water equivalents are measured at elevations from 0 to 4564 ft (0 to 1391 m) in the Brooks Range for the area from the Sagavanirktok River on the west to the Canning River on the east (Tables 1, 2, 3). These are the first snow survey data collected/available for this area.

Liston and Sturm (2002) mentioned that there are two distinctly different snow regimes across the adjacent Kuparuk basin, uplands and coastal. Using this knowledge, snow sites over the Sagavanirktok River domain are classified over the coastal plain (Table 3) and uplands (i.e. foothills and mountains). The coastal sites are the sites located below elevation isoline of 500 ft (152 m) and those above are referred as uplands sites. Uplands snow sites are, in turn, separated into foothills and mountains, based on surrounding topography (Tables 1, 2). Elevation is not representative, because in the mountains regions most of the snow survey sites are located in the valley bottoms that can be safely accessed by helicopter (Figure 1).

SNOW DEPTH AND SNOW WATER EQUIVALENT

Snowpack water equivalent distribution is highly heterogeneous over the area. On local scale of few hundred of meters, it results from interaction between vegetation, terrain and wind-blowing snow redistribution. It also varies on a regional scale of several tens to hundred of kilometers, in response to regional precipitation, air temperature, humidity and wind gradients (Liston and Sturm, 2002).

Average coastal plain densities (0.514 slug ft^{-3} / 265 kg m^{-3}) are similar to foothills average snow density (0.488 slug ft^{-3} / 251 kg m^{-3}) and higher than mountains average snow density (0.376 slug ft^{-3} / 194 kg m^{-3}). The difference between average snow density from coastal and mountainous sites is 27% (Tables 4, 5, 6).

Coastal plain average snow water equivalent is 3.4 in (8.7 cm), and snow depth average is 13.0 in (33.1 cm). Foothills average snow water equivalent is 3.0 in (7.6 cm), and snow depth average is 12.4 in (31.5 cm). Mountains average snow water equivalent is 2.9 in (7.3 cm), and snow depth average is 13.7 in (34.9 cm).

Due to complex terrain and wind interaction in uplands, a simple average from point observations in mountains (Table 4) is not recommended to consider as the aerial SWE estimate. The reason for that is the location of the most uplands sites at the valley bottoms. The north-south trending valleys of the Brooks Range are subjected to strong katabatic winds that contribute to snow redistribution and sublimation processes. Liston and Sturm (2004) suggested that reduced snow cover in these areas is thought to be the result of these strong winds flowing through the valleys towards the north.

Please, refer to work plan 2006 (snow data analysis section) that contains detailed description of methods and models to quantify realistically the spatial snow water equivalent distribution in the domain before onset of ablation.

SUMMARY

2006 snow data survey is considered to be a base dataset for successful estimation of basin wide maximum snowpack water content before melt. In this region no other ground snow information is otherwise available. Compiled dataset will also be used as input into hydrological models for runoff estimation of both gauged and ungauged watersheds. This pattern of snow distribution, with the coastal plain having the highest SWE, was quite similar between the Kuparuk Foothills area and this study. In general, the snowpack was lighter than average and snowmelt was average for this region.

REFERENCES

Liston, G. E., and Sturm, M., 2002: Winter precipitation patterns in Arctic Alaska determined from a blowing-snow model and snow-depth observations. Journal of Hydrometeorology, 3: 646–659.

Liston, G. E., and Sturm, M., 2004: The role of winter sublimation in the Arctic moisture budget. Nordic Hydrology, 35(4): 325–334.

Rovansek, R.J., Kane, D.L., and Hinzman, L.D., 1993: Improving estimates of snowpack water equivalent using double sampling. Proceedings of the 61st Western Snow Conference, p. 157-163.

Woo, M., 1997: A guide for ground based measurement of Arctic snow cover. Report for Atmospheric Environment Service, Canada