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Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and David E. Knapp, Editors

Volume 22

BOREAS HYD-3 Snow Measurements

J.P. Hardy and R.E. Davis

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

July 2000

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BOREAS HYD-3 Snow Measurements

Janet P. Hardy, Robert E. Davis

Summary

The BOREAS HYD-3 team collected several data sets related to the hydrology of forested areas. This data set contains measurements of snow depth, snow density in 3-cm intervals, an integrated snow pack density and snow water equivalent (SWE), and snow pack physical properties from snow pit evaluation taken in 1994 and 1996. The data were collected from several sites in both the SSA and the NSA. A variety of standard tools were used to measure the snow pack properties, including a meter stick (snow depth), a 100-cc snow density cutter, a dial stem thermometer, and the Canadian snow sampler as used by HYD-4 to obtain a snow pack-integrated measure of SWE. This study was undertaken to predict spatial distributions of snow properties important to the hydrology, remote sensing signatures, and the transmissivity of gases through the snow. The data are available in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification
BOREAS HYD-03 Snow Measurements

1.2 Data Set Introduction
The data pertaining to this documentation include all snow-related measurements made during the field campaigns. These measurements include snow depth and density in 3-cm intervals and integrated throughout the snow pack as well as snow temperatures. The data were collected from several sites in the BOReal Ecosystem-Atmosphere Study (BOREAS) Southern Study Area (SSA) and Northern Study Area (NSA). A variety of standard tools were used to measure the snow pack properties,

including a meter stick (snow depth), a 100-cc snow density cutter, a dial stem thermometer, and the Canadian snow sampler as used by Hydrology (HYD)-04 to obtain a snow pack-integrated measure of snow water equivalent (SWE).

1.3 Objective/Purpose

This study was undertaken to predict spatial distributions of snow properties important to the hydrology, remote sensing signatures, and the transmissivity of gases through the snow.

1.4 Summary of Parameters

Parameters measured with respect to this documentation are snow depth variability and snow density specific to land cover types at the flux tower sites visited. These data allow the calculation of SWE. Additional parameters measured include snow pack temperatures.

1.5 Discussion

This study was conducted under the hypothesis that energy transfer and SWE would vary spatially as a function of both the canopy closure and the distance from tree stems. Therefore, to obtain an accurate spatial average, random locations were measured irrespective of the location of trees. The representativeness of the snow depths to the site depends partially on the number of measurements. Raw measurements of snow depths near tree stems and under different canopy closures are available from the Principal Investigator (PI). Certain snow metamorphic processes are driven by snow pack temperature gradients, and an effort was made to measure that variable in the boreal forests.

1.6 Related Data Sets

BOREAS HYD-04 Standard Snow Course Data
BOREAS HYD-04 Areal Snow Course Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

Robert E. Davis
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U.S. Army Cold Regions Research and Engineering Laboratory (CRREL)

2.2 Title of Investigation

Distributed Energy Transfer Modeling in Snow and Soil for Boreal Ecosystems

2.3 Contact Information

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3. Theory of Measurements

Several random snow depth measurements were made over the area around each site to assess the variability of snow depth. At one or more locations in the forest, snow pits were dug and profiles of the snow density and temperature were included in the measurements. The snow density profiles were used to calculate an average snow pack density to test the assumption that average density was more conservative than depth. This assumption proved valid; thus, measurements of snow depth, in conjunction with average snow pack density, provide accurate estimates of SWE. SWE is the vertical depth of water that would be obtained by melting the snow.

Snow temperature measurements were made in part to initialize the snow process model as well as to provide important information for estimating the timing of snow ablation.

4. Equipment

4.1 Sensor/Instrument Description

- Centimeter scale (meter stick) - for snow depth measurements.
- 100-cc snow density cutter - allows weight measurement of 100-cc volume of snow, from which the snow density is determined. The dimensions of the cutter are 3 cm x 5.5 cm x 6 cm. This technique measures snow density at intervals of 3 cm height.
- Electronic top loader balance - provides weight of snow, which allows determination of snow densities accurate within 5% (cutter and scale together).
- Canadian snow sampler - measures snow depth and provides data on an integrated snow density and SWE.

4.1.1 Collection Environment

All data were collected during winter environments. The equipment used is designed for winter use, so the collection environment was appropriate for these measurements.

4.1.2 Source/Platform

Ground.

4.1.3 Source/Platform Mission Objectives

This work was undertaken at several sites within the BOREAS modeling area to obtain a better understanding of the variations of snow depth and density in different land cover types.

4.1.4 Key Variables

Snow depth, snow pack density, SWE, and snow temperature.

4.1.5 Principles of Operation

The centimeter scale is inserted into the snow pack, and the depth of the snow is read from the scale. For snow density, a known volume of snow is weighed and its volume density is then determined from the formula in Section 9.1. Two different techniques were used to determine snow density. One used the 100-cc snow cutter, and the other used the Canadian snow sampler.

Snow temperatures are read from a horizontally inserted thermometer.

4.1.6 Sensor/Instrument Measurement Geometry

Not applicable.

4.1.7 Manufacturer of Sensor/Instrument

Snow density cutter:
SNOWMETRICS
Box 52
Wilson, WY 83014
(307) 739-9458

Electronic balance:
ACCULAB
8 Pheasant Run
Newtown, PA 18940
(215) 579-3170

Canadian snow sampler:
(No manufacturer's address was given)
1-Eastern Snow Conference (ESC)-30 snow sampler
1-spring balance for ESC-30
1-cradle
1-measuring stick/ruler (cm)

Thermometer:
Cole - Palmer Instrument Co.
7425 North Oak Park Ave.
Niles, IL 60714-9930

4.2 Calibration

The electronic balance was calibrated using a 200-gram calibration weight. Thermometers were calibrated using the ice bath calibration method. This method involves placing the temperature sensors in a well-mixed combination of water and ice, which will have a known temperature of 0 °C. Thermometers are then adjusted as close as possible to 0 °C while in the ice bath.

4.2.1 Specifications

Not available.

4.2.1.1 Tolerance

Electronic balance: Accuracy is within 5% when used in conjunction with snow density cutter (+/- 0.1 g when used alone).

Thermometer:
Range: -50 °C to 150 °C +/- 0.8% full-scale precision or +/- 1.5 °C
Resolution = 0.1 °C

4.2.2 Frequency of Calibration

Prior to field use.

4.2.3 Other Calibration Information

Not available.

5. Data Acquisition Methods

100-cc Snow Cutter:

Snow depth measurements were made with a centimeter scale by walking through the area taking random depth measurements. A zero snow depth occurred when the measurement landed at a tree stem. For the snow density profiles, a representative area was chosen, a vertical exposure of the snow pack was exposed to the north, and snow density measurements were made with the 100-cc snow cutter every 3 vertical cm until the entire snow pack was measured (i.e., a 45-cm-deep snow pack would require 15 measurements of snow density to obtain the snow pack density profile).

Canadian Snow Sampler:

The Canadian snow sampler is used by inserting the tube through the snow pack to the soil, twisting the tube, and removing the tube and snow core. The tube and snow core are weighted using the spring scale, and the snow depth is read from the centimeter scale on the tube.

Snow Temperature:

Snow temperature measurements are made by inserting the thermometer horizontally into the snow pit at 10-cm height intervals. Temperatures are read directly off the thermometer dial to the nearest degree once the thermometer has stabilized.

6. Observations

6.1 Data Notes

None.

6.2 Field Notes

None.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

Point measurements were scattered over a 1-hectare area within 50 meters of the flux tower, if it was near a flux tower site. The following coordinates are approximate and based on the North American Datum of 1983 (NAD83).

SWE:

SITE_ID	LONGITUDE	LATITUDE
SSA-OBS-HYD03-HYD03-SWE01	105.11779W	53.98717N
SSA-AGR-HYD03-HYD03-SWE01	104.78041W	53.57649N
NSA-OJP-FLXTR-HYD03-SWE01	98.62028W	55.93011N
NSA-9BS-HYD3A-HYD03-SWE01	97.89026W	55.81011N
NSA-YBS-HYD03-HYD03-SWE01	97.87026W	55.83011N
NSA-MIX-HYD03-HYD03-SWE01	97.84025W	55.85011N
NSA-9BS-HYD3B-HYD03-SWE01	97.82025W	55.87011N
NSA-YJP-FLXTR-HYD03-SWE01	98.29027W	55.90011N
SSA-MIX-110B1-HYD03-SWE01	105.82606W	54.58848N
SSA-999-110C1-HYD03-SWE01	105.82461W	54.57386N
SSA-ASP-110E1-HYD03-SWE01	105.81461W	54.54696N
SSA-BSH-110G1-HYD03-SWE01	105.81221W	54.52526N
SSA-ASP-110H1-HYD03-SWE01	105.8067W	54.50956N
SSA-BRN-110J1-HYD03-SWE01	105.8123W	54.48146N
SSA-ASP-110K1-HYD03-SWE01	105.81W	54.46696N
SSA-CLR-110L1-HYD03-SWE01	105.8024W	54.43746N
SSA-YJP-122D1-HYD03-SWE01	104.61914W	53.84426N
SSA-999-122E1-HYD03-SWE01	104.61944W	53.84916N
SSA-MIX-122F1-HYD03-SWE01	104.62214W	53.85586N
SSA-MIX-122G1-HYD03-SWE01	104.60623W	53.89836N
SSA-999-WSK01-HYD03-SWE01	106.0705W	53.94005N
SSA-9OA-FLXTR-HYD03-SWE01	106.19051W	53.63005N
NSA-OBS-FLXTR-HYD03-SWE01	98.48027W	55.8801N
SSA-OJP-HYD03-HYD03-SWE01	104.69044W	53.92006N
SSA-9PR-HYD03-HYD03-SWE01	105.27048W	53.56005N

Snow Depth Sites:

SITE_ID	LONGITUDE	LATITUDE
SSA-OJP-FLXTR-HYD03-SDP01	104.69203W	53.91634N
SSA-AGR-HYD03-HYD03-SDP01	104.78041W	53.57649N
SSA-WAT-FLXTR-HYD03-SDP01	106.04122W	53.83105N
SSA-9OA-FLXTR-HYD03-SDP01	106.19779W	53.62889N
SSA-OBS-FLXTR-HYD03-SDP01	105.11779W	53.98717N

Snow Pits:

SITE_ID	LONGITUDE	LATITUDE
SSA-AGR-HYD03-HYD03-SPT01	104.78041W	53.57649N
SSA-WAT-FLXTR-HYD03-SPT01	106.04122W	53.83105N
SSA-9OA-FLXTR-HYD03-SPT01	106.19779W	53.62889N
SSA-OBS-FLXTR-HYD03-SPT01	105.11779W	53.98717N
SSA-999-WSK04-HYD03-SPT01	106.09068W	53.9232N
SSA-OJP-FLXTR-HYD03-SPT01	104.69203W	53.91634N

Snow Temperature:

SITE_ID	LONGITUDE	LATITUDE
NSA-9BS-HYD3B-HYD03-SHT06	97.82025W	55.87011N
NSA-9BS-HYD3A-HYD03-SHT01	97.89026W	55.81011N
NSA-9BS-HYD3A-HYD03-SHT02	97.89026W	55.81011N
NSA-YBS-HYD03-HYD03-SHT03	97.87026W	55.83011N
NSA-MIX-HYD03-HYD03-SHT04	97.84025W	55.85011N
NSA-9BS-HYD3B-HYD03-SHT05	97.82025W	55.87011N
NSA-YJP-FLXTR-HYD03-SHT01	98.29027W	55.90011N
NSA-OJP-FLXTR-HYD03-SHT01	98.62028W	55.93011N
NSA-OBS-FLXTR-HYD03-SHT01	98.48027W	55.8801N
SSA-9PR-HYD03-HYD03-SHT01	105.27048W	53.56005N

Subcanopy Meteorological:

SITE_ID	LONGITUDE	LATITUDE
SSA-OBS-FLXTR-HYD03-SCM01	105.11779W	53.98717N
SSA-OJP-FLXTR-HYD03-SCM01	104.69203W	53.91634N
SSA-9OA-FLXTR-HYD03-SCM01	106.19779W	53.62889N

Subcanopy Radiation:

SITE_ID	LONGITUDE	LATITUDE
SSA-OBS-FLXTR-HYD03-SCR01	105.11779W	53.98717N
SSA-9OA-FLXTR-HYD03-SCR01	106.19779W	53.62889N
SSA-OJP-FLXTR-HYD03-SCR01	104.69203W	53.91634N

7.1.2 Spatial Coverage Map
Not available.

7.1.3 Spatial Resolution
Point source data (snow pits).

7.1.4 Projection
The locations of these point sites are based on NAD83.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

```
1994: Focused Field Campaign-Winter (FFC-W) (05-Feb-1994 to 15-Feb-1994)
      and FFC-Thaw (FFC-T) (17-Apr-1994 to 27-Apr-1994)
1996: FFC-W (29-Feb-1996 to 12-Mar-1996)
```

7.2.2 Temporal Coverage Map

```
05-Feb-1994       SA-Prairie
06-Feb-1994       SSA-Old Jack Pine (OJP)
07-08-Feb-1994    SSA: Transect near Montreal Lake (Gamma Calibration Lines)
09-Feb-1994       SSA-Waskesiu Lake
10-Feb-1994       SSA-Old Aspen (OA)
13-Feb-1994       NSA: near AYJP on Gillam Road.
14-Feb-1994       NSA-Young Jack Pine (YJP)
15-Feb-1994       NSA-OJP

17-Apr-1994       NSA-YJP
18-Apr-1994       NSA-Old Black Spruce (OBS)
20-Apr-1994       NSA-OBS
22-Apr-1994       NSA-YJP
24-Apr-1994       NSA-YJP
24-Apr-1994       NSA-YJP
25-Apr-1994       NSA-OJP
26-Apr-1994       NSA-YJP
27-Apr-1994       NSA-OPEN

29-Feb-1996       SSA-OBS
01-Mar-1996       SSA-AG
02-Mar-1996       SSA-OBS
04-Mar-1996       SSA-OA
05-Mar-1996       SSA-OJP
07-Mar-1996       SSA-Namekus
11-Mar-1996       SSA-OJP
12-Mar-1996       SSA-Waskesiu
```

7.2.3 Temporal Resolution

Snow depth, SWE: biweekly during FFC-W 1994, 3-5 days during FFC-T 1994, more frequently depending on weather.

Snow temperatures: FFC-W 1994 - 1-3 days (less for the upper portion of the snow pack). FFC-T 1994 - Once the snow pack is isothermal at 0 °C during the thaw period, the top portion of the snow pack may show some diurnal temperature fluctuations, but otherwise the snow pack may remain at the melting point until the snow is gone.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

HYD03_SWE_DATA

```
         Column Name
------------------------------
SITE_NAME
SUB_SITE
DATE_OBS
MEAN_SNOW_DEPTH
SWE_NUM_OBS
MEAN_SNOW_DENSITY
CALC_SWE
CAN_SNOW_SAMPLER_SWE
CAN_SNOW_SAMPLER_NUM_OBS
CRTFCN_CODE
REVISION_DATE
```

HYD03_SNOWTEMP_DATA

```
         Column Name
------------------------------
SITE_NAME
SUB_SITE
DATE_OBS
SNOW_HT
SNOW_TEMP
CRTFCN_CODE
REVISION_DATE
```

HYD03_SWE_96_DATA

```
         Column Name
------------------------------
SITE_NAME
SUB_SITE
DATE_OBS
SAMPLE_ID
SNOW_DEPTH
CAN_SNOW_SAMPLER_SWE
SNOW_DENSITY
TREE_ZONE
COMMENTS
REVISION_DATE
CRTFCN_CODE
```

HYD03_SNOW_DEPTHS_96_DATA

Column Name
SITE_NAME
SUB_SITE
DATE_OBS
SAMPLE_ID
SNOW_DEPTH
CRTFCN_CODE
REVISION_DATE

HYD03_SNOW_PITS_96_DATA

Column Name
SITE_NAME
SUB_SITE
DATE_OBS
SNOW_LAYER_TOP_HT
SNOW_LAYER_BOTM_HT
SNOW_DENSITY_1
SNOW_DENSITY_2
SNOW_DENSITY_3
PARM_VALUE_FLAGS
SNOW_TEMP
SNOW_TEMP_HT
CRTFCN_CODE
REVISION_DATE

7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

HYD03_SWE_DATA

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
MEAN_SNOW_DEPTH	The average depth of snow.
SWE_NUM_OBS	Number of snow water equivalent (SWE) measurements taken.
MEAN_SNOW_DENSITY	The mean snow pack density.
CALC_SWE	Calculated snow water equivalent.

CAN_SNOW_SAMPLER_SWE	This is the snow water equivalent that was measured from the Canadian snow sampler.
CAN_SNOW_SAMPLER_NUM_OBS	This is the number of measurements that were made at the site with the Canadian snow sampler.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

HYD03_SNOWTEMP_DATA

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
SNOW_HT	The height above solid surface at which the snow measurement was taken.
SNOW_TEMP	The temperature of the snow at the reported snow height.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

HYD03_SWE_96_DATA

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to

	an instrument.
DATE_OBS	The date on which the data were collected.
SAMPLE_ID	The sample identifier used by data collectors.
SNOW_DEPTH	The depth of snow on the ground.
CAN_SNOW_SAMPLER_SWE	This is the snow water equivalent that was measured from the Canadian snow sampler.
SNOW_DENSITY	The density of the snow.
TREE_ZONE	The relative location of the snow measurements with respect to a tree or the trees around it.
COMMENTS	Descriptive information to clarify or enhance the understanding of the other entered data.
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).

HYD03_SNOW_DEPTHS_96_DATA

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
SAMPLE_ID	The sample identifier used by data collectors.
SNOW_DEPTH	The depth of snow on the ground.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

HYD03_SNOW_PITS_96_DATA

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.

SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
SNOW_LAYER_TOP_HT	The upper height of a layer or "horizon" of snow.
SNOW_LAYER_BOTM_HT	The lower height of a layer or "horizon" of snow.
SNOW_DENSITY_1	The first snow density measurement.
SNOW_DENSITY_2	The second snow density measurement.
SNOW_DENSITY_3	The third snow density measurement.
PARM_VALUE_FLAGS	This contains values or codes that indicate special conditions for the data parameters. N/A = not applicable.
SNOW_TEMP	The temperature of the snow at the reported snow height.
SNOW_TEMP_HT	The height above the surface at which the snow temperature measurement was made.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

HYD03_SWE_DATA

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
MEAN_SNOW_DEPTH	[millimeters]
SWE_NUM_OBS	[counts]
MEAN_SNOW_DENSITY	[kilograms][meter^-3]
CALC_SWE	[millimeters]
CAN_SNOW_SAMPLER_SWE	[millimeters]
CAN_SNOW_SAMPLER_NUM_OBS	[unitless]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

HYD03_SNOWTEMP_DATA

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
SNOW_HT	[millimeters]
SNOW_TEMP	[degrees Celsius]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

HYD03_SWE_96_DATA

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
SAMPLE_ID	[none]
SNOW_DEPTH	[millimeters]
CAN_SNOW_SAMPLER_SWE	[millimeters]
SNOW_DENSITY	[kilograms][meter^-3]
TREE_ZONE	[none]
COMMENTS	[none]
REVISION_DATE	[DD-MON-YY]
CRTFCN_CODE	[none]

HYD03_SNOW_DEPTHS_96_DATA

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
SAMPLE_ID	[none]
SNOW_DEPTH	[millimeters]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

HYD03_SNOW_PITS_96_DATA

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
SNOW_LAYER_TOP_HT	[millimeters]
SNOW_LAYER_BOTM_HT	[millimeters]
SNOW_DENSITY_1	[kilograms][meter^-3]
SNOW_DENSITY_2	[kilograms][meter^-3]
SNOW_DENSITY_3	[kilograms][meter^-3]
PARM_VALUE_FLAGS	[none]
SNOW_TEMP	[degrees Celsius]
SNOW_TEMP_HT	[millimeters]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

HYD03_SWE_DATA

Column Name	Data Source
SITE_NAME	[Assigned by BORIS]
SUB_SITE	[Assigned by BORIS]
DATE_OBS	[Supplied by Investigator]
MEAN_SNOW_DEPTH	[Supplied by Investigator]
SWE_NUM_OBS	[Supplied by Investigator]

MEAN_SNOW_DENSITY	[Supplied by Investigator]
CALC_SWE	[Supplied by Investigator]
CAN_SNOW_SAMPLER_SWE	[Supplied by Investigator]
CAN_SNOW_SAMPLER_NUM_OBS	[Supplied by Investigator]
CRTFCN_CODE	[Assigned by BORIS]
REVISION_DATE	[Assigned by BORIS]

HYD03_SNOWTEMP_DATA

Column Name	Data Source
SITE_NAME	[Assigned by BORIS]
SUB_SITE	[Assigned by BORIS]
DATE_OBS	[Supplied by Investigator]
SNOW_HT	[Supplied by Investigator]
SNOW_TEMP	[Supplied by Investigator]
CRTFCN_CODE	[Assigned by BORIS]
REVISION_DATE	[Assigned by BORIS]

HYD3_SWE_96_DATA

Column Name	Data Source
SITE_NAME	[Assigned by BORIS]
SUB_SITE	[Assigned by BORIS]
DATE_OBS	[Supplied by Investigator]
SAMPLE_ID	[Supplied by Investigator]
SNOW_DEPTH	[Supplied by Investigator]
CAN_SNOW_SAMPLER_SWE	[Supplied by Investigator]
SNOW_DENSITY	[Supplied by Investigator]
TREE_ZONE	[Supplied by Investigator]
COMMENTS	[Supplied by Investigator]
REVISION_DATE	[Assigned by BORIS]
CRTFCN_CODE	[Assigned by BORIS]

HYD03_SNOW_DEPTHS_96_DATA

Column Name	Data Source
SITE_NAME	[Assigned by BORIS]
SUB_SITE	[Assigned by BORIS]
DATE_OBS	[Supplied by Investigator]
SAMPLE_ID	[Supplied by Investigator]
SNOW_DEPTH	[Supplied by Investigator]
CRTFCN_CODE	[Assigned by BORIS]
REVISION_DATE	[Assigned by BORIS]

HYD03_SNOW_PITS_96_DATA

Column Name	Data Source
SITE_NAME	[Assigned by BORIS]
SUB_SITE	[Assigned by BORIS]
DATE_OBS	[Supplied by Investigator]
SNOW_LAYER_TOP_HT	[Supplied by Investigator]
SNOW_LAYER_BOTM_HT	[Supplied by Investigator]
SNOW_DENSITY_1	[Supplied by Investigator]
SNOW_DENSITY_2	[Supplied by Investigator]

SNOW_DENSITY_3	[Supplied by Investigator]
PARM_VALUE_FLAGS	[Supplied by Investigator]
SNOW_TEMP	[Supplied by Investigator]
SNOW_TEMP_HT	[Supplied by Investigator]
CRTFCN_CODE	[Assigned by Investigator]
REVISION_DATE	[Assigned by Investigator]

7.3.5 Data Range

The following table gives information about the parameter values found in the data files on the CD-ROM.

HYD03_SWE_DATA

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-9BS-HYD3A	SSA-YJP-122D1	None	None	None	None
SUB_SITE	HYD03-SWE01	HYD03-SWE03	None	None	None	None
DATE_OBS	05-FEB-94	27-APR-94	None	None	None	None
MEAN_SNOW_DEPTH	160	540	None	None	None	None
SWE_NUM_OBS	1	385	None	None	None	None
MEAN_SNOW_DENSITY	161	335	-999	None	None	None
CALC_SWE	37	118	-999	None	None	None
CAN_SNOW_SAMPLER_SWE	28	58	-999	None	None	Blank
CAN_SNOW_SAMPLER_NUM_OBS	1	5	-999	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	21-JUL-95	21-JUL-95	None	None	None	None

HYD03_SNOWTEMP_DATA

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-9BS-HYD3A	SSA-9PR-HYD03	None	None	None	None
SUB_SITE	HYD03-SHT01	HYD03-SHT06	None	None	None	None
DATE_OBS	05-FEB-94	27-APR-94	None	None	None	None
SNOW_HT	0	1250	None	None	None	None
SNOW_TEMP	-17.5	0	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	21-JUL-95	21-JUL-95	None	None	None	None

HYD03_SWE_96_DATA

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	SSA-9OA-FLXTR	SSA-OJP-HYD03	None	None	None	None
SUB_SITE	HYD03-SWE01	HYD03-SWE01	None	None	None	None
DATE_OBS	29-FEB-96	05-MAR-96	None	None	None	None
SAMPLE_ID	1	20	None	None	None	None
SNOW_DEPTH	230	510	None	None	None	None

CAN_SNOW_SAMPLER_SWE	30	90	None	None	None	None
SNOW_DENSITY	100	217	None	None	None	None
TREE_ZONE	N/A	N/A	None	None	None	None
COMMENTS	N/A	N/A	None	None	None	None
REVISION_DATE	31-JAN-97	31-JAN-97	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None

HYD03_SNOW_DEPTHS_96_DATA

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	SSA-9OA-FLXTR	SSA-WAT-FLXTR	None	None	None	None
SUB_SITE	HYD03-SDP01	HYD03-SDP01	None	None	None	None
DATE_OBS	29-FEB-96	11-MAR-96	None	None	None	None
SAMPLE_ID			None	None	None	None
SNOW_DEPTH	0	560	None	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	13-JAN-97	13-JAN-97	None	None	None	None

HYD03_SNOW_PITS_96_DATA

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	SSA-999-WSK04	SSA-WAT-FLXTR	None	None	None	None
SUB_SITE	HYD03-SPT01	HYD03-SPT01	None	None	None	None
DATE_OBS	29-FEB-96	12-MAR-96	None	None	None	None
SNOW_LAYER_TOP_HT	20	410	None	None	None	Blank
SNOW_LAYER_BOTM_HT	0	380	None	None	None	Blank
SNOW_DENSITY_1	114	397	None	None	None	Blank
SNOW_DENSITY_2	117	401	None	None	None	Blank
SNOW_DENSITY_3	119	322	None	None	None	Blank
PARM_VALUE_FLAGS	N/A	N/A	None	None	None	Blank
SNOW_TEMP	-21	0	None	None	None	Blank
SNOW_TEMP_HT	0	400	None	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	28-JAN-97	28-JAN-97	None	None	None	None

Minimum Data Value -- The minimum value found in the column.
Maximum Data Value -- The maximum value found in the column.
Missng Data Value -- The value that indicates missing data. This is used to indicate that an attempt was made to determine the parameter value, but the attempt was unsuccessful.
Unrel Data Value -- The value that indicates unreliable data. This is used to indicate an attempt was made to determine the parameter value, but the value was deemed to be unreliable by the analysis personnel.
Below Detect Limit -- The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined

```
                     that the parameter value was below the detection
                     limit of the instrumentation.
Data Not Cllctd   -- This value indicates that no attempt was made to
                     determine the parameter value.  This usually
                     indicates that BORIS combined several similar but
                     not identical data sets into the same data base table
                     but this particular science team did not
                     measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.
N/A   -- Indicates that the value is not applicable to the respective column.
None  -- Indicates that no values of that sort were found in the column.
----------------------------------------------------------------------------------
```

7.4 Sample Data Record

The following are wrapped versions of data records from a sample data file on the CD-ROM.

HYD03_SWE_DATA (1994)

```
SITE_NAME,SUB_SITE,DATE_OBS,MEAN_SNOW_DEPTH,SWE_NUM_OBS,MEAN_SNOW_DENSITY,
CALC_SWE,CAN_SNOW_SAMPLER_SWE,CAN_SNOW_SAMPLER_NUM_OBS,CRTFCN_CODE,REVISION_DATE
'NSA-YJP-FLXTR','HYD03-SWE01',14-FEB-94,380.0,79,180,86,,,'CPI',21-JUL-95
```

HYD03_SNOWTEMP_DATA

```
SITE_NAME,SUB_SITE,DATE_OBS,SNOW_HT,SNOW_TEMP,CRTFCN_CODE,REVISION_DATE
'NSA-MIX-HYD03','HYD03-SHT04',13-FEB-94,400,-13.0,'CPI',21-JUL-95
```

HYD03_SWE_96_DATA

```
SITE_NAME,SUB_SITE,DATE_OBS,SAMPLE_NUM,SNOW_DEPTH,CAN_SNOW_SAMPLER_SWE,
SNOW_DENSITY,TREE_ZONE,COMMENTS,REVISION_DATE,CRTFCN_CODE
'SSA-OBS-HYD03','HYD03-SWE01',29-FEB-96,1,400.0,60,150,'NONE','At snow pit',
31-JAN-97,'CPI'
```

HYD03_SNOW_DEPTHS_96_DATA

```
SITE_NAME,SUB_SITE,DATE_OBS,SAMPLE_ID,SNOW_DEPTH,CRTFCN_CODE,REVISION_DATE
'SSA-OBS-FLXTR','HYD03-SDP01',29-FEB-96,'97',400.0,'CPI',13-JAN-97
```

HYD03_SNOW_PITS_96_DATA

```
SITE_NAME,SUB_SITE,DATE_OBS,SNOW_LAYER_TOP_HT,SNOW_LAYER_BOTM_HT,SNOW_DENSITY_1,
SNOW_DENSITY_2,SNOW_DENSITY_3,PARM_VALUE_FLAGS,SNOW_TEMP,SNOW_TEMP_HT,
CRTFCN_CODE,REVISION_DATE
'SSA-OBS-FLXTR','HYD03-SPT01',29-FEB-96,390,360.0,116,117,,'',-11.0,350,'CPI',
28-JAN-97
```

8. Data Organization

8.1 Data Granularity

The smallest amount of data that can be ordered from this data set is a day's worth of data for a particular site.

8.2 Data Format(s)

The Compact Disk-Read-Only Memory (CD-ROM) files contain American Standard Code for Information Interchange (ASCII) numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields.

Each data file on the CD-ROM has four header lines of Hyper-Text Markup Language (HTML) code at the top. When viewed with a Web browser, this code displays header information (data set title, location, date, acknowledgments, etc.) and a series of HTML links to associated data files and related data sets. Line 5 of each data file is a list of the column names, and line 6 and following lines contain the actual data.

9. Data Manipulations

9.1 Formulae

To determine snow pack SWE:

Snow depth (mm) x [snow density (kg/m^3)/1000] = SWE (mm)

9.1.1 Derivation Techniques and Algorithms

Not applicable.

9.2 Data Processing Sequence

9.2.1 Processing Steps

For snow density and SWE:

- Determine mean snow depth at site.
- Determine mean snow pack density at site (if more than one snow pack density measurement exists at any site, then average the means).
- Use formula above to calculate SWE.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

None.

9.3.2 Calculated Variables

None.

9.4 Graphs and Plots

None.

10. Errors

10.1 Sources of Error

- In measuring snow depth, the probe may at times hit a fallen branch or understory and underestimate snow depth at that point.
- Snow pack density data were often derived from a single snow pit evaluation. Error would be reduced if it was practical to obtain several measurements of mean snow pack density.
- An unresolved, systematic discrepancy exists between the determination of SWE using the Canadian snow sampler and the technique using mean snow depths and mean snow pack density determined from the 100-cc density cutter.

10.2 Quality Assessment

10.2.1 Data Validation by Source

Comparison was attempted with HYD-04 snow survey data. Data were similar, but time and location of data collection points were not the same and therefore cannot be directly compared.

10.2.2 Confidence Level/Accuracy Judgment

The confidence in snow depth data is a function of the number of measurements made (n) at each site. The more measurements made, the better the variability is represented and therefore the greater the confidence.

The snow temperature data are good indications of the temperature gradient at that point. The temperature gradient will vary with snow depth, proximity to a tree, or snow pack base (i.e., forest floor, ice on pond).

10.2.3 Measurement Error for Parameters

Snow density measurement accuracy = 5%.

10.2.4 Additional Quality Assessments

The data were doublechecked. Calculations were performed at least twice, and more often if a discrepancy existed.

10.2.5 Data Verification by Data Center

These data were reviewed to make sure that data were loaded properly.

11. Notes

11.1 Limitations of the Data

Snow depth and density and temperatures can be highly variable in forested environments. A single data point cannot accurately represent a forest snow pack. Also, during periods of thaw, the snow pack changes rapidly, and a measurement made on one day may not have much bearing on the snow pack the next day. Note that on 09-Mar-1996, the daily high air temperature reached 0 °C and stayed above freezing for most of the remainder of the field campaign. During this period, the snow pack changed rapidly.

11.2 Known Problems with the Data

An unresolved, systematic discrepancy exists between the determination of SWE using the Canadian snow sampler and the technique using mean snow depths and mean snow pack density determined from the 100-cc density cutter.

11.3 Usage Guidance
See Section 11.1.

11.4 Other Relevant Information
Canadian snow samplers are brittle when very cold, as Piers Sellers found out.

12. Application of the Data Set

This data set could be used for a quantitative analysis to compare SWE among different land cover types. The data are also useful for snow modeling purposes or estimating the water potentially available to the soil systems.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description
An undetermined spreadsheet software program was used to organize the data.

14.2 Software Access
None given.

15. Data Access

The snow measurement data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information
For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification
Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/ [Internet Link].

15.3 Procedures for Obtaining Data
Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by

contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

Contact BOREAS Information System (BORIS) staff.

16.2 Film Products

Contact BORIS staff.

16.3 Other Products

These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

Not applicable.

17.2 Journal Articles and Study Reports

Davis, R.E., C. Woodcock, and J.P. Hardy. 1996. Toward spatially distributed modeling of snow in the boreal forest. Eos Transactions, AGU 1995 Fall Meeting, Abstract, p. 218.

Davis, R.E., J.P. Hardy, W. Ni, C. Woodcock, J.C. McKenzie, R. Jordan, and X. Li. 1997. Variation of snow cover ablation in the boreal forest: A sensitivity study on the effects of conifer canopy. Journal of Geophysical Research. 102(D24):29,389-29,395.

Hardy, J.P., R.E. Davis, and G.C. Winston. 1995. Evolution of factors affecting gas transmissivity of snow in the boreal forest. In: Biogeochemistry of Seasonally Snow-Covered Catchments (ed. by K. Tonnessen, M.W. Williams, and M. Tranter) (Proc. Boulder Symp., July 1995). IAHS publication no. 228, p. 51-60.

Hardy, J.P., R.E. Davis, and J.C. McKenzie. 1995. Snow Distribution Around Trees: Incorporation of snow interception patterns into spatially distributed snow models. Eos Transactions, AGU 1995 Fall Meeting, Abstract, p. 202.

Hardy, J.P., R.E. Davis, and R. Jordan. 1996. Snow melt modeling in the boreal forest. Eos Transactions, AGU 1996 Fall Meeting, abstract, p. 196.

Hardy, J.P., R.E. Davis, R. Jordan, X. Li, C. Woodcock, W. Ni, and J.C. McKenzie. 1997. Snow ablation modeling at the stand scale in a boreal jack pine forest. Journal of Geophysical Research. 102(D24): 29,397-29,405.

Hardy, J.P., R.E. Davis, R. Jordan, W. Ni and C. Woodcock, 1998. Snow ablation modelling in a mature aspen stand of the boreal forest. Hydrological Processes, 12 (10/11), p. 1763-1778.

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

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Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102(D24): 28,731-28,770.

Winston, G.C., B.B. Stephens, E.T. Sundquist, J.P. Hardy, and R.E. Davis. 1995. Seasonal variability in gas transport through snow in a boreal forest. In: Biogeochemistry of Seasonally Snow-Covered Catchments (ed. by K. Tonnessen, M.W. Williams, and M. Tranter) (Proc. Boulder Symp., July 1995). IAHS publication no. 228, p. 61-70.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

```
ASCII   - American Standard Code for Information Interchange
BOREAS  - BOReal Ecosystem-Atmosphere Study
BORIS   - BOREAS Information System
cc      - cubic centimeters
CGR     - Certified by Group
CPI     - Certified by Principal Investigator
CPI-??? - CPI but questionable
CRREL   - Cold Regions Research Engineering Laboratory
DAAC    - Distributed Active Archive Center
EOS     - Earth Observing System
EOSDIS  - EOS Data and Information System
FFC-T   - Focused Field Campaign-Thaw
FFC-W   - Focused Field Campaign-Winter
GIS     - Geographic Information System
GMT     - Greenwich Mean Time
GSFC    - Goddard Space Flight Center
HTML    - Hyper-Text Markup Language
HYD     - Hydrology
NAD83   - North American Datum of 1983
NASA    - National Aeronautics and Space Administration
NSA     - BOREAS Northern Study Area
OBS     - Old Black Spruce
OJP     - Old Jack Pine
ORNL    - Oak Ridge National Laboratory
PANP    - Prince Albert National Park
PI      - Principal Investigator
PRE     - Preliminary
SSA     - BOREAS Southern Study Area
SWE     - Snow Water Equivalent
URL     - Uniform Resource Locator
YBS     - Young Black Spruce
YJP     - Young Jack Pine
```

20. Document Information

20.1 Document Revision Date

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20.2 Document Review Date(s)

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20.3 Document ID

20.4 Citation

When using these data, please include the following acknowledgment and cite the following papers:

The BOREAS HYD-03 subcanopy meteorological data were collected and processed by Janet P. Hardy and Robert E. Davis of US Army CRREL. Their efforts in making these data available are greatly appreciated.

Davis, R.E., J. P. Hardy, W. Ni, C. Woodcock, C.J. McKenzie, R. Jordan and X. Li, 1997. Variation of snow cover ablation in the boreal forest: A sensitivity study on the effects of conifer canopy. J. of Geophys. Res., 102 ($N_2$4), 29,389-29,396, December 26, 1997.

Hardy, J.P., R.E. Davis, R. Jordan, W. Ni and C. Woodcock, 1998. Snow ablation modelling in a mature aspen stand of the boreal forest. Hydrological Processes, 12 (10/11), p. 1763-1778.

Hardy, J.P., R.E. Davis, R. Jordan, X. Li, C. Woodcock, W. Ni and J.C. McKenzie, 1997. Snow ablation modeling at the stand scale in a boreal jack pine forest. , J. of Geophys. Res., 102 (N24), 29,397-29,406, December 26, 1997.

If using data from the BOREAS CD-ROM series, also reference the data as:

R.E. Davis, "Distributed Energy Transfer Modeling in Snow and Soil for Boreal Ecosystems." In Collected Data of The Boreal Ecosystem-Atmosphere Study. Eds. J. Newcomer, D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers. CD-ROM. NASA, 2000.

Also, cite the BOREAS CD-ROM set as:

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM. NASA, 2000.

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13. ABSTRACT *(Maximum 200 words)*

The BOREAS HYD-3 team collected several data sets related to the hydrology of forested areas. This data set contains measurements of snow depth, snow density in 3-cm intervals, an integrated snow pack density and snow water equivalent (SWE), and snow pack physical properties from snow pit evaluation taken in 1994 and 1996. The data were collected from several sites in both the SSA and the NSA. A variety of standard tools were used to measure the snow pack properties, including a meter stick (snow depth), a 100-cc snow density cutter, a dial stem thermometer, and the Canadian snow sampler as used by HYD-4 to obtain a snow pack-integrated measure of SWE. This study was undertaken to predict spatial distributions of snow properties important to the hydrology, remote sensing signatures, and the transmissivity of gases through the snow. The data are available in tabular ASCII files.

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