NASA/TM—2000–209891, Vol. 28

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

Forrest G. Hall and Karl Huemmrich, Editors

Volume 28

BOREAS HYD-5 Winter Surface Flux Data

R. Harding

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

July 2000

The NASA STI Program Office ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program Office plays a key part in helping NASA maintain this important role.

The NASA STI Program Office is operated by Langley Research Center, the lead center for NASA's scientific and technical information. The NASA STI Program Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program Office is also NASA's institutional mechanism for disseminating the results of its research and development activities. These results are published by NASA in the NASA STI Report Series, which includes the following report types:

- TECHNICAL PUBLICATION. Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA's counterpart of peer-reviewed formal professional papers but has less stringent limitations on manuscript length and extent of graphic presentations.
- TECHNICAL MEMORANDUM. Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.
- CONTRACTOR REPORT. Scientific and technical findings by NASA-sponsored contractors and grantees.
- CONFERENCE PUBLICATION. Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or cosponsored by NASA.
- SPECIAL PUBLICATION. Scientific, technical, or historical information from NASA programs, projects, and mission, often concerned with subjects having substantial public interest.
- TECHNICAL TRANSLATION. English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services that complement the STI Program Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results . . . even providing videos.

For more information about the NASA STI Program Office, see the following:

- Access the NASA STI Program Home Page at http://www.sti.nasa.gov/STI-homepage.html
- E-mail your question via the Internet to help@sti.nasa.gov
- Fax your question to the NASA Access Help Desk at (301) 621-0134
- Telephone the NASA Access Help Desk at (301) 621-0390
- Write to:
  NASA Access Help Desk
  NASA Center for AeroSpace Information
  7121 Standard Drive
  Hanover, MD 21076-1320

NASA/TM—2000–209891, Vol. 28

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

Forrest G. Hall and Karl Huemmrich, Editors

Volume 28

BOREAS HYD-5 Winter Surface Flux Data

Richard Harding
Institute of Hydrology, U.K.

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

July 2000

Available from:

NASA Center for AeroSpace Information
7121 Standard Drive
Hanover, MD 21076-1320
Price Code: A17

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Price Code: A10

BOREAS HYD-5 Winter Surface Flux Data

Richard Harding

Summary

The BOREAS HYD-5 team collected tower flux, surface meteorological, and surface temperature data on a frozen lake (Namekus Lake) and in a mature jack pine forest in the Beartrap Creek watershed. Both sites were located in the BOREAS SSA. The objective of this study was to characterize the winter energy and water vapor fluxes, as well as related properties (such as snow density, depth, temperature, and melt) for forested and nonforested areas of the boreal forest. Data were collected on Namekus Lake in the winters of 1994 and 1996, and at Beartrap Creek in the winter of 1994 only. The data are available in tabular ASCII files.

Table of Contents

1) Data Set Overview
2) Investigator(s)
3) Theory of Measurements
4) Equipment
5) Data Acquisition Methods
6) Observations
7) Data Description
8) Data Organization
9) Data Manipulations
10) Errors
11) Notes
12) Application of the Data Set
13) Future Modifications and Plans
14) Software
15) Data Access
16) Output Products and Availability
17) References
18) Glossary of Terms
19) List of Acronyms
20) Document Information

1. Data Set Overview

1.1 Data Set Identification

BOREAS HYD-05 Bear Trap Creek and Namekus Lake Winter Surface Flux Data

1.2 Data Set Introduction

Surface flux, meteorological, and temperature data were collected on the frozen surface of Namekus Lake and in a mature, slightly open, jack pine stand (Pinus banksia) in the Beartrap Creek catchment. Both sites are in the Prince Albert National Park (PANP) in the BOReal Ecosystem-Atmosphere Study (BOREAS) Southern Study Area (SSA). Data were collected on Namekus Lake in the winters of 1994 and 1996 and at Beartrap Creek in the winter of 1994 only.

1.3 Objective/Purpose

The objective of this study was to characterize the winter energy and water vapor fluxes, as well as related properties (such as snow density, depth, temperature, and melt) for forested and nonforested areas of the boreal forest.

1.4 Summary of Parameters and Variables

Latent heat flux, sensible heat flux, net radiation, humidity, wind speed and direction, air temperature, incident and reflected shortwave radiation, and surface temperature data were collected.

1.5 Discussion

A comparison of a surface meteorology and energy balance of a snow-covered lake and an adjacent forest area was made. There were small, but measurable, contrasts in the temperature and wind speed measured over the lake and forest (the lake was cooler and windier), but it is the comparison of the energy balance of the forest and the open snow surface that is dramatic: the mean net radiation flux was into the forest canopy but out of the snow-covered lake. Similarly, when the forest canopy was clear of snow, the sensible heat flux was of different sign (and magnitude) over the forest and lake. When the forest canopy was snow-covered, the partition of the sensible and latent heat fluxes was different again, exhibiting a large upward latent heat flux and a compensating downward sensible heat flux.

1.6 Related Data Sets

Tower flux measurements made in the winter at other sites:

BOREAS TF-01 SSA OA Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-03 NSA OBS Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-09 SSA OBS Tower Flux, Meteorological, and Soil Temperature Data

Other measurements made at the HYD-05 sites:

BOREAS HYD-03 Snow Measurements

2. Investigator(s)

2.1 Investigator(s) Name and Title

Richard Harding
Institute of Hydrology

2.2 Title of Investigation

The Regional Representation of the Energy and Moisture Fluxes from Snow Covered Areas in the BOREAS Experiment

2.3 Contact Information

Contact 1:

Richard Harding
Institute of Hydrology
Maclean Building
Crowmarsh Gifford
Wallingford Oxfordshire
OX10 8BB United Kingdom
44 1491 838800
44 1491 832256 (fax)
R.Harding@unixa.nerc-wallingford.ac.uk

Contact 2:
K. Fred Huemmrich
University of Maryland
Code 923
NASA GSFC
Greenbelt, MD 20771
(301) 286-4862
(301) 286-0239 (fax)
Karl.Huemmrich@gsfc.nasa.gov

3. Theory of Measurements

This study collected data to contrast the winter energy and water vapor fluxes for forested and nonforested areas of the boreal forest. The long, cold winter characteristic of the boreal forest causes cessation of growth for 5 to 7 months of the year and is the most distinguishing feature of this biome. The components of the energy balance, which determine the net energy supply to the canopy and the snow surface, are small during this winter period - with direct effects on biological activity. Most of the components of the energy balance: the radiation flux (solar and thermal), sensible heat flux (turbulent transfer of heat from the surface to the atmosphere), latent heat flux (evaporative cooling or warming upon condensation), and to a lesser degree the soil heat flux, are strongly influenced by the presence and depth of snow cover and its interaction with vegetation. Snow reflects most incident solar radiation and hence dramatically reduces the net radiative energy input. However, when the snow covers a forest canopy, the multiple reflections within the canopy scatter rather than reflect the majority of incident radiation, and the albedo remains low (Harding and Pomeroy, 1996; van de Hulst, 1957; Oke, 1978).

4. Equipment

4.1 Sensor/Instrument Description

4.1.1 Collection Environment

There were two sites in this study. The first site was a mature, slightly open, jack pine stand (Pinus banksia) in the Beartrap Creek catchment. The fetch was level and reasonably uniform for at least 100 m. The pine canopy was 16-22 m in height with a sparse understory of deciduous bushes. The winter "leaf" (branch and needle) area index of this stand was 2.2, and the canopy cover of sky was 82% measured with a LI-COR LAI-2000 Canopy Density meter (Gower and Norman, 1991). The second site was on the snow-covered frozen surface of Namekus Lake, 10 km southeast of the jack pine stand. The surface was quite smooth (snow over ice), and the fetch exceeded 700 m. Data were collected at both sites during winter periods, experiencing temperatures as low as -37 ºC on the lake to a high of 18 ºC over the forest.

4.1.2 Source/Platform

The Beartrap Creek site was equipped with a 26-m meteorological tower from which measurements were taken of shortwave radiation (downward and reflected) and net all-wave radiation above and below the canopy, along with vertical profiles of temperature, humidity, snow particle flux, and wind speed through the canopy. A "Hydra" eddy correlation system was also operated from the top of the tower for direct measurement of sensible and latent heat fluxes (Shuttleworth et al., 1988). Hydra was developed at the Institute of Hydrology. It consists of a vertical component sonic anemometer, a fine wire thermocouple thermometer, an infrared absorption hydrometer, and a fast response cup anemometer. A second eddy correlation system measuring only sensible heat flux was operated from the tower. This consisted of a "solent" sonic anemometer (Gill Instruments Ltd.,

Lymington, U.K.), a fine wire thermocouple, and a Campbell Scientific CR21 with software similar to that described by Shuttleworth et al. (1988).

The net all-wave radiation above the canopy was measured with two instruments, both on short (~2 m) booms at the top of the tower; a Middleton radiometer and a Radiation Energy Balance Systems (REBS), Seattle, Washington) Q*5. Below the canopy, shortwave and net all-wave radiation were measured with "Delta 7" tube radiometers (Delta-T Devices Ltd., Cambridge, U.K.). These tubes (almost 1 meter in length) average the speckled light found beneath the canopy (Szeicz et al,. 1964).

The Namekus Lake site was equipped with a 3-m mast with instruments to measure the two shortwave components of the radiation balance, the all-wave net radiation, temperature, humidity, snow particle flux, and wind speed (at 1, 2, and 3 m) above the snow surface. A second Hydra was operated to provide fluxes of heat and water vapor.

Nipher-shielded snow gauges under the forest canopy and in a nearby open area provided weekly snowfall and snow interception. Weekly snow surveys, both underneath the forest canopy and on the lake, were undertaken to give average snow depth and the water equivalent of the pack.

4.1.3 Source/Platform Mission Objectives

Towers were established to support the measurement of tower flux, surface meteorological, and surface temperature data on a frozen lake (Namekus Lake) and in a mature jack pine forest (Beartrap Creek).

4.1.4 Key Variables

Latent heat flux, sensible heat flux, net radiation, humidity, wind speed and direction, air temperature, incident and reflected shortwave radiation, and surface temperature data were collected.

4.1.5 Principles of Operation

The Hydra, based on the eddy correlation technique, consists of sensors and real-time and offline computers. It is a complete instrumentation system, designed specifically to provide routine measurements of the surface energy fluxes with minimum supervision.

4.1.6 Sensor/Instrument Measurement Geometry

Beartrap Creek site: At the top of a 26-m meteorological tower: Hydra eddy correlation system and a Solent sonic anemometer. On short (~2 m) booms at the top of the tower: a Middleton radiometer and a REBS Q*5. Below the canopy: Delta 7 tube radiometers.

Namekus Lake site: A 3-m mast with a Hydra eddy correlation system and instruments to measure the two shortwave components of the radiation balance, the all-wave net radiation, temperature, humidity, snow particle flux, and wind speed (at 1, 2, and 3 m) above the snow surface.

The Hydra has to be set up so that the sonic anemometer is at right angles to the local stream lines of the flow.

Nipher-shielded snow gauges under the forest canopy and in a nearby open area.

4.1.7 Manufacturer of Sensor/Instrument

Hydra eddy correlation system: Developed at the Institute of Hydrology Hydra consists of a vertical component sonic anemometer, a fine wire thermocouple thermometer, an infrared absorption hydrometer, and a fast response cup anemometer.

Solent sonic anemometer:
Gill Instruments Limited
Solent House
Cannon Street
Lymington,
Hampshire SO41 9BR
UK

Campbell Scientific CR21:
Campbell Scientific
P.O. Box 551
Logan, UT 84321
USA

REBS Q*5:
Radiation Energy Balance Systems
P.O. Box 15512
Seattle, WA 98115-0512
USA

Delta 7 tube radiometers:
Delta-T Devices Ltd.
128 Low Rd, Burwell,
Cambs CB5 .0EJ
UK

4.2 Calibration

4.2.1 Specifications

A constant check of the Hydra's performance is made on a 24-hour basis by checking that the sum of sensible and latent heat fluxes is equivalent to the available energy for this same period. ±10% is considered good, although ±20% is quite common, especially when weather conditions are changeable. If errors become consistent or if a failure occurs, a spare set of sensors and electronics is carried with each Hydra, which is designed to accept changeover in the field easily.

4.2.1.1 Tolerance

Not known.

4.2.2 Frequency of Calibration

The Hydra is calibrated typically once a year if it is not overseas for longer than this.

4.2.3 Other Calibration Information

Not known.

5. Data Acquisition Methods

None given.

6. Observations

6.1 Data Notes

None given.

6.2 Field Notes

None given.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

All data were collected at two sites in PANP in the BOREAS SSA. The North American Datum of 1983 (NAD83) coordinates of these sites were:

Site	Latitude	Longitude
Beartrap Creek	53.84779° N	106.17090° W
Namekus Lake	53.83101° N	106.04127° W

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

The data represent point source measurements taken at the given locations. The location and size of the footprint from which the measurements were made varied with ambient meteorological conditions. At the Beartrap Creek site, the fetch was level and reasonably uniform for at least 100 m. At the Namekus Lake site the surface was quite smooth (snow over ice) during data collection, and the fetch exceeded 700 m.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

For the Beartrap Creek site, measurements are available from 03-Feb to 17-Apr-1994. For the Namekus Lake site, measurements are available from 10-Feb to 28-Mar-1994 and 17-Mar to 07-Apr-1996.

7.2.2 Temporal Coverage Map

All data were collected at the Beartrap Creek and Namekus Lake sites.

7.2.3 Temporal Resolution

Data values are reported hourly.

7.3 Data Characteristics

7.3.1 Parameter/Variable

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

HYD05 Namekus Lake Data

Column Name
SITE_NAME
SUB_SITE
DATE_OBS
TIME_OBS
AIR_TEMP_ABV_CNPY
NET_RAD_ABV_CNPY
NET_RAD_2
ABS_HUM_ABV_CNPY
WIND_SPEED_ABV_CNPY
SENSIBLE_HEAT_FLUX_ABV_CNPY
LATENT_HEAT_FLUX_ABV_CNPY
FRICTION_VELOC_ABV_CNPY
WIND_SPEED_2M
WIND_SPEED_1M
QUALITY_INDEX
DOWN_SOLAR_RAD_ABV_CNPY
UP_SOLAR_RAD_ABV_CNPY
AIR_TEMP_2M
WIND_DIR_ABV_CNPY
SURFACE_TEMP
CRTFCN_CODE
REVISION_DATE

HYD05 Bear Trap Forest Data

Column Name
SITE_NAME
SUB_SITE
DATE_OBS
TIME_OBS
AIR_TEMP_ABV_CNPY
ABS_HUM_ABV_CNPY
WIND_SPEED_VERTICAL
WIND_SPEED_ABV_CNPY
FRICTION_VELOC_ABV_CNPY
SENSIBLE_HEAT_FLUX_ABV_CNPY
LATENT_HEAT_FLUX_ABV_CNPY
NET_RAD_ABV_CNPY
QUALITY_INDEX
U_WIND_SPEED_SOLENT
V_WIND_SPEED_SOLENT
W_WIND_SPEED_SOLENT
AIR_TEMP_SONIC
EDDY_COVARIANCE
SENSIBLE_HEAT_FLUX_SOLENT
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:

HYD05 Namekus Lake 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.
TIME_OBS	The Greenwich Mean Time (GMT) when the data were collected.
AIR_TEMP_ABV_CNPY	The air temperature measured above the canopy.
NET_RAD_ABV_CNPY	The net radiation measured above the canopy.
NET_RAD_2	The second net radiation measurement.
ABS_HUM_ABV_CNPY	The absolute humidity measured above the canopy.
WIND_SPEED_ABV_CNPY	The wind speed measured above the canopy.
SENSIBLE_HEAT_FLUX_ABV_CNPY	The sensible heat flux measured above the canopy.
LATENT_HEAT_FLUX_ABV_CNPY	The latent heat flux measured above the canopy.
FRICTION_VELOC_ABV_CNPY	The friction velocity above the canopy.
WIND_SPEED_2M	The wind speed measured at 2 meters above the surface.
WIND_SPEED_1M	The wind speed measured at 1 meter above the surface.
QUALITY_INDEX	The quality index where 0 denotes good data, 1-999 is fair, and 1000 is probably bad data.
DOWN_SOLAR_RAD_ABV_CNPY	The downward (incoming) solar radiation measured above the canopy.
UP_SOLAR_RAD_ABV_CNPY	The reflected (outgoing) solar radiation measured above the canopy.
AIR_TEMP_2M	Air temperature measured at a height of 2 meters above the surface.
WIND_DIR_ABV_CNPY	The wind direction measured above the canopy.
SURFACE_TEMP	The surface temperature.
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.

HYD05 Bear Trap Forest 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.
TIME_OBS	The Greenwich Mean Time (GMT) when the data were collected.
AIR_TEMP_ABV_CNPY	The air temperature measured above the canopy.
ABS_HUM_ABV_CNPY	The absolute humidity measured above the canopy.
WIND_SPEED_VERTICAL	The vertical wind speed.
WIND_SPEED_ABV_CNPY	The wind speed measured above the canopy.
FRICTION_VELOC_ABV_CNPY	The friction velocity above the canopy.
SENSIBLE_HEAT_FLUX_ABV_CNPY	The sensible heat flux measured above the canopy.
LATENT_HEAT_FLUX_ABV_CNPY	The latent heat flux measured above the canopy.
NET_RAD_ABV_CNPY	The net radiation measured above the canopy.
QUALITY_INDEX	The quality index where 0 denotes good data, 1-999 is fair, and 1000 is probably bad data.
U_WIND_SPEED_SOLENT	The U component wind speed from the Solent sensor.
V_WIND_SPEED_SOLENT	The V component wind speed from the Solent sensor.
W_WIND_SPEED_SOLENT	The W component wind speed from the Solent sensor.
AIR_TEMP_SONIC	The air temperature measured from a fine wire thermocouple, mounted near the sonic anemometer.
EDDY_COVARIANCE	The eddy covariance.
SENSIBLE_HEAT_FLUX_SOLENT	The sensible heat flux measured from the Solent sensor.
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:

HYD05 Namekus Lake Data

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
AIR_TEMP_ABV_CNPY	[degrees Celsius]
NET_RAD_ABV_CNPY	[Watts][meter^-2]
NET_RAD_2	[Watts][meter^-2]
ABS_HUM_ABV_CNPY	[grams][meter^-3]
WIND_SPEED_ABV_CNPY	[meters][second^-1]
SENSIBLE_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
LATENT_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
FRICTION_VELOC_ABV_CNPY	[meters][second^-1]
WIND_SPEED_2M	[meters][second^-1]
WIND_SPEED_1M	[meters][second^-1]
QUALITY_INDEX	[unitless]
DOWN_SOLAR_RAD_ABV_CNPY	[Watts][meter^-2]
UP_SOLAR_RAD_ABV_CNPY	[Watts][meter^-2]
AIR_TEMP_2M	[degrees Celsius]
WIND_DIR_ABV_CNPY	[degrees from North]
SURFACE_TEMP	[degrees Celsius]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

HYD05 Bear Trap Forest Data

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
AIR_TEMP_ABV_CNPY	[degrees Celsius]
ABS_HUM_ABV_CNPY	[grams][meter^-3]
WIND_SPEED_VERTICAL	[meters][second^-1]
WIND_SPEED_ABV_CNPY	[meters][second^-1]
FRICTION_VELOC_ABV_CNPY	[meters][second^-1]
SENSIBLE_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
LATENT_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
NET_RAD_ABV_CNPY	[Watts][meter^-2]
QUALITY_INDEX	[unitless]
U_WIND_SPEED_SOLENT	[meters][second^-1]
V_WIND_SPEED_SOLENT	[meters][second^-1]
W_WIND_SPEED_SOLENT	[meters][second^-1]
AIR_TEMP_SONIC	[degrees Celsius]
EDDY_COVARIANCE	[unknown]
SENSIBLE_HEAT_FLUX_SOLENT	[Watts][meter^-2]
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:

HYD05 Namekus Lake Data

Column Name	Data Source
SITE_NAME	[Assigned by BORIS.]
SUB_SITE	[Assigned by BORIS.]
DATE_OBS	[Supplied by Investigator.]
TIME_OBS	[Supplied by Investigator.]
AIR_TEMP_ABV_CNPY	[Thermocouple]
NET_RAD_ABV_CNPY	[Net radiometer]
NET_RAD_2	[Net radiometer]
ABS_HUM_ABV_CNPY	[psychrometer]
WIND_SPEED_ABV_CNPY	[anemometer]
SENSIBLE_HEAT_FLUX_ABV_CNPY	[Hydra]
LATENT_HEAT_FLUX_ABV_CNPY	[Hydra]
FRICTION_VELOC_ABV_CNPY	[Hydra]
WIND_SPEED_2M	[anemometer]
WIND_SPEED_1M	[anemometer]
QUALITY_INDEX	[Supplied by Investigator.]
DOWN_SOLAR_RAD_ABV_CNPY	[solarimeter]
UP_SOLAR_RAD_ABV_CNPY	[solarimeter]
AIR_TEMP_2M	[Thermocouple]
WIND_DIR_ABV_CNPY	[windvane]
SURFACE_TEMP	[Thermocouple]
CRTFCN_CODE	[Assigned by BORIS.]
REVISION_DATE	[Assigned by BORIS.]

HYD05 Bear Trap Forest Data

Column Name	Data Source
SITE_NAME	[Assigned by BORIS.]
SUB_SITE	[Assigned by BORIS.]
DATE_OBS	[Supplied by Investigator.]
TIME_OBS	[Supplied by Investigator.]
AIR_TEMP_ABV_CNPY	[Thermocouple]
ABS_HUM_ABV_CNPY	[psychrometer]
WIND_SPEED_VERTICAL	[Hydra]
WIND_SPEED_ABV_CNPY	[Hydra]
FRICTION_VELOC_ABV_CNPY	[Hydra]
SENSIBLE_HEAT_FLUX_ABV_CNPY	[Hydra]
LATENT_HEAT_FLUX_ABV_CNPY	[Hydra]
NET_RAD_ABV_CNPY	[Net radiometer]
QUALITY_INDEX	[Solent anemometer]
U_WIND_SPEED_SOLENT	[Solent anemometer]
V_WIND_SPEED_SOLENT	[Solent anemometer]
W_WIND_SPEED_SOLENT	[Solent anemometer]
AIR_TEMP_SONIC	[Thermocouple]
EDDY_COVARIANCE	[Sonic anemometer]
SENSIBLE_HEAT_FLUX_SOLENT	[Solent anemometer]
CRTFCN_CODE	[Assigned by BORIS.]
REVISION_DATE	[Assigned by BORIS.]

7.3.5 Data Range

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

HYD05 Namekus Lake Data

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	SSA-WAT-FLXTR	SSA-WAT-FLXTR	None	None	None	None
SUB_SITE	HYD05-FLX01	HYD05-FLX01	None	None	None	None
DATE_OBS	10-FEB-94	11-APR-96	None	None	None	None
TIME_OBS	0	2300	None	None	None	None
AIR_TEMP_ABV_CNPY	-23.4	9.5	-999	None	None	Blank
NET_RAD_ABV_CNPY	-86	130	-999	None	None	Blank
NET_RAD_2	-84.7	462.6	None	None	None	None
ABS_HUM_ABV_CNPY	-.2	8.7	-999	None	None	Blank
WIND_SPEED_ABV_CNPY	.1	14.3	-999	None	None	Blank
SENSIBLE_HEAT_FLUX_ABV_CNPY	-109	58	-999	None	None	Blank
LATENT_HEAT_FLUX_ABV_CNPY	-9073	308	-999	None	None	Blank
FRICTION_VELOC_ABV_CNPY	-9999	.44	-999	None	None	Blank
WIND_SPEED_2M	0	13.21	None	None	None	None
WIND_SPEED_1M	0	12.04	-999	None	None	None
QUALITY_INDEX	0	3220	-999	None	None	Blank
DOWN_SOLAR_RAD_ABV_CNPY	-4.337	773	None	None	None	None
UP_SOLAR_RAD_ABV_CNPY	-2.179	582.1	None	None	None	None
AIR_TEMP_2M	-37.57	16.81	None	None	None	None
WIND_DIR_ABV_CNPY	.017	359.8	-999	None	None	Blank
SURFACE_TEMP	-20.1	13.5	-999	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	23-JUL-98	24-JUL-98	None	None	None	None

HYD05 Bear Trap Forest Data

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	SSA-CLR-FLXTR	SSA-CLR-FLXTR	None	None	None	None
SUB_SITE	HYD05-FLX01	HYD05-FLX01	None	None	None	None
DATE_OBS	01-FEB-94	17-APR-94	None	None	None	None
TIME_OBS	0	2300	None	None	None	None
AIR_TEMP_ABV_CNPY	-13.5	18.6	-999	None	None	None
ABS_HUM_ABV_CNPY	.6	5.1	-999	None	None	None
WIND_SPEED_VERTICAL	-.91	1.35	-999	None	None	None
WIND_SPEED_ABV_CNPY	.1	11.6	-999	None	None	None
FRICTION_VELOC_ABV_CNPY	-.15	1.13	-999	None	None	None
SENSIBLE_HEAT_FLUX_	-93	999	-999	None	None	None

```
ABV_CNPY
LATENT_HEAT_FLUX_ABV -349          467          -999    None    None    None
_CNPY
NET_RAD_ABV_CNPY     -94           550          -999    None    None    None
QUALITY_INDEX        -9999         9999         -999    None    None    Blank
U_WIND_SPEED_SOLENT  -.25          16.62        -999    None    None    None
V_WIND_SPEED_SOLENT  -6.28         16.39        -999    None    None    None
W_WIND_SPEED_SOLENT  -4.42         13.97        -999    None    None    None
AIR_TEMP_SONIC       -54           18.5         -999    None    None    None
EDDY_COVARIANCE      -29.14        36.69        -999    None    None    None
SENSIBLE_HEAT_FLUX_  -69.05        327.94       -999    None    None    None
SOLENT
CRTFCN_CODE          CPI           CPI          None    None    None    None
REVISION_DATE        24-JUL-98     24-JUL-98    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 sample data files on the CD-ROM.

HYD05 Namekus Lake Data

```
SITE_NAME,SUB_SITE,DATE_OBS,TIME_OBS,AIR_TEMP_ABV_CNPY,NET_RAD_ABV_CNPY,
NET_RAD_2,ABS_HUM_ABV_CNPY,WIND_SPEED_ABV_CNPY,SENSIBLE_HEAT_FLUX_ABV_CNPY,
LATENT_HEAT_FLUX_ABV_CNPY,FRICTION_VELOC_ABV_CNPY,WIND_SPEED_2M,WIND_SPEED_1M,
QUALITY_INDEX,DOWN_SOLAR_RAD_ABV_CNPY,UP_SOLAR_RAD_ABV_CNPY,AIR_TEMP_2M,
WIND_DIR_ABV_CNPY,SURFACE_TEMP,CRTFCN_CODE,REVISION_DATE
'SSA-WAT-FLXTR','HYD05-FLX01',10-FEB-94,1900,,-23.0,0.0,.8,1.1,-999.0,0.0,-.1,
.818,.498,,308.2,248.9,-24.17,,-999.0,'CPI',23-JUL-98
```

```
HYD05 Bear Trap Forest Data

SITE_NAME,SUB_SITE,DATE_OBS,TIME_OBS,AIR_TEMP_ABV_CNPY,ABS_HUM_ABV_CNPY,
WIND_SPEED_VERTICAL,WIND_SPEED_ABV_CNPY,FRICTION_VELOC_ABV_CNPY,
SENSIBLE_HEAT_FLUX_ABV_CNPY,LATENT_HEAT_FLUX_ABV_CNPY,NET_RAD_ABV_CNPY,
QUALITY_INDEX,U_WIND_SPEED_SOLENT,V_WIND_SPEED_SOLENT,W_WIND_SPEED_SOLENT,
AIR_TEMP_SONIC,EDDY_COVARIANCE,SENSIBLE_HEAT_FLUX_SOLENT,CRTFCN_CODE,
REVISION_DATE
'SSA-CLR-FLXTR','HYD05-FLX01',01-FEB-94,600,-999.0,-999.0,-999.0,-999.0,-999.0,
-999.0,-999.0,-999.0,-999,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,'CPI',
24-JUL-98
```

8. Data Organization

8.1 Data Granularity

The smallest unit of data tracked by the BOREAS Information System (BORIS) was data collected at a given site on a given date.

8.2 Data Format

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

See Shuttleworth et al. (1988) for a description of formulas used in the Hydra data processing.

9.1.1 Derivation Techniques and Algorithms

None given.

9.2 Data Processing Sequence

9.2.1 Processing Steps

See Shuttleworth et al. (1988) for a description of the Hydra data processing. BORIS staff processed these data by:

- Reviewing the initial data files and loading them online for BOREAS team access.
- Designing relational data base tables to inventory and store the data.
- Loading the data into the relational data base tables.
- Working with the team to document the data set.
- Extracting the data into logical files.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments
None.

9.3.2 Calculated Variables
None given.

9.4 Graphs and Plots
None.

10. Errors

10.1 Sources of Error
Factors contributing to instrument errors include signal-to-noise ratio, height of the instrument, and sensor separation. Nonsteady conditions and surface inhomogeneities are sources of natural variability.

10.2 Quality Assessment
At the Namekus Lake site, the sum of the turbulent fluxes agrees reasonably with the input net radiation.

At the Beartrap Creek site, the net radiation was measured by two completely separate systems, which agreed to within 10 W/m^2, and the sensible heat fluxes were measured by two systems, and again the agreement was within a few watts per square meter. Finally, measurement of the latent heat flux using eddy correlation is strongly supported by measurements from the weighted tree, which gave a continuous output of the weight of the snow on the forest canopy (the weighted tree data were not submitted to BORIS, contact the investigator for these data).

10.2.1 Data Validation by Source
Over the Namekus Lake, the sum of the turbulent fluxes agrees reasonably with the input net radiation (particularly considering the small size of the fluxes). Unfortunately, neither snowmelt nor ground (ice) heat fluxes were measured at this site; but the energy closure, neglecting these, suggests they were small. However, there appears to be an imbalance between the sensible and latent heat fluxes and the radiation input in the forest; the energy from net radiation and downward sensible heat flux could not provide sufficient energy to supply the high observed evaporation. Measurements of ground heat flux are typically 2 W/m^2 and so could not provide this energy. It seems unlikely that the flux measurements were seriously in error: the net radiation was measured by two completely separate systems, which agreed to within 10 W/m^2. The sensible heat fluxes were again measured by two systems, and again the agreement was within a few watts per square meter. Finally, measurement of the latent heat flux using eddy correlation is strongly supported by measurements from the weighted tree. It is possible that there was some strong horizontal advection at this site (with the localized radiation measurements being unrepresentative of the "footprint" of the measurements of the turbulent fluxes), or there is also the possibility of some large change of heat storage within the trunk space.

10.2.2 Confidence Level/Accuracy Judgment
None given.

10.2.3 Measurement Error for Parameters
None given.

10.2.4 Additional Quality Assessments
None given.

10.2.5 Data Verification by Data Center

Data were examined to check for spikes, values that are four standard deviations from the mean, long periods of constant values, and missing data.

11. Notes

11.1 Limitations of the Data

These data were collected while the ground was snow covered.

11.2 Known Problems with the Data

There appears to be an imbalance between the sensible and latent heat fluxes and the radiation input in the forest at the Beartrap Creek site; the energy from net radiation and downward sensible heat flux could not provide sufficient energy to supply the high observed evaporation. Measurements of ground heat flux are typically 2 W/m^2 and so could not provide this energy. It is possible that there was some strong horizontal advection at this site (with the localized radiation measurements being unrepresentative of the "footprint" of the measurements of the turbulent fluxes), or there is also the possibility of some large change of heat storage within the trunk space. This imbalance obviously requires further study.

11.3 Usage Guidance

None given.

11.4 Other Relevant Information

None given.

12. Application of the Data Set

This data set is useful for studying the wintertime energy and water balance of both open and forested sites.

13. Future Modifications and Plans

None given.

14. Software

14.1 Software Description

None given.

14.2 Software Access

None given.

15. Data Access

The winter flux 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

None.

16.2 Film Products

None.

16.3 Other Products

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

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

None.

17.2 Journal Articles and Study Reports

Gower, S.T. and J.M. Norman. 1991. Rapid estimation of leaf area index in conifer and broad-leaf plantations. Ecology. 72: 1896-1900.

Harding, R.J. and J.W. Pomeroy. 1996. The energy balance of the winter boreal landscape. Journal of Climate. 9(11): 2778-2787.

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.

Oke, T.R. 1978. Boundary Layer Climates. Methuen and Sons, pp. 110-112.

Pomeroy, J.W. and K. Dion. 1996. Winter radiation extinction and reflection in a boreal pine canopy: measurements and modeling. Hydrol. Process. 10(12): 1591-1608.

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).

Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

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.

Shuttleworth, W.J., J.H. C. Gash, C.R. Lloyd, D.D. McNeil, C.J. Moore, and J.S. Wallace. 1988. An integrated micrometeorological system for evaporation measurement. Agric. Meteor. 43: 295-317.

Szeicz, G., J.L. Monteith, and J. dos Santos. 1964. A tube solimeter to measure radiation among plants. J. Appl. Ecol. 1: 169-174.

Van de Hulst, H.C. 1957. Light Scattering by Small Particles. Wiley and Sons, 470 pp.

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
CD-ROM	- Compact Disk-Read-Only Memory
DAAC	- Distributed Active Archive Center
EOS	- Earth Observing System
EOSDIS	- EOS Data and Information System
GIS	- Geographic Information System
GMT	- Greenwich Mean Time
GSFC	- Goddard Space Flight Center
HTML	- HyperText Markup Language
HYD	- Hydrology
NAD83	- North American Datum of 1983
NASA	- National Aeronautics and Space Administration
NSA	- Northern Study Area
OBS	- Old Black Spruce
ORNL	- Oak Ridge National Laboratory
PANP	- Prince Albert National Park
SSA	- Southern Study Area
TF	- Tower Flux
URL	- Uniform Resource Locator

20. Document Information

20.1 Document Revision Date

Written: 13-Jul-1998
Revised: 30-Jul-1999

20.2 Document Review Date(s)

BORIS Review: 07-May-1999
Science Review: 17-Aug-1998

20.3 Document ID

20.4 Citation

When using these data, please include the following acknowledgment as well as citations of relevant papers in Section 17.2:

Data were collected by R.J. Harding. Please cite the following article when using these data:

Harding, R.J. and J.W. Pomeroy. 1996. The energy balance of the winter boreal landscape. Journal of Climate. 9(11): 2778-2787.

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

Harding, R., "The Regional Representation of the Energy and Moisture Fluxes from Snow Covered Areas in the BOREAS Experiment." 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.

20.5 Document Curator

20.6 Document URL

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	July 2000	Technical Memorandum

4. TITLE AND SUBTITLE
Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)
BOREAS HYD-5 Winter Surface Flux Data

5. FUNDING NUMBERS
923
RTOP: 923-462-33-01

6. AUTHOR(S)
Richard Harding
Forrest G. Hall and Karl Huemmrich, Editors

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS (ES)
Goddard Space Flight Center
Greenbelt, Maryland 20771

8. PEFORMING ORGANIZATION REPORT NUMBER
2000-03136-0

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS (ES)
National Aeronautics and Space Administration
Washington, DC 20546-0001

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
TM—2000–209891
Vol. 28

11. SUPPLEMENTARY NOTES
R. Harding: Institute of Hydrology, U.K.; K. Huemmrich: University of Maryland

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Unclassified–Unlimited
Subject Category: 43
Report available from the NASA Center for AeroSpace Information,
7121 Standard Drive, Hanover, MD 21076-1320. (301) 621-0390.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The BOREAS HYD-5 team collected tower flux, surface meteorological, and surface temperature data on a frozen lake (Namekus Lake) and in a mature jack pine forest in the Beartrap Creek watershed. Both sites were located in the BOREAS SSA. The objective of this study was to characterize the winter energy and water vapor fluxes, as well as related properties (such as snow density, depth, temperature, and melt) for forested and nonforested areas of the boreal forest. Data were collected on Namekus Lake in the winters of 1994 and 1996, and at Beartrap Creek in the winter of 1994 only. The data are available in tabular ASCII files.

14. SUBJECT TERMS
BOREAS, hydrology, winter energy, water vapor flux.

15. NUMBER OF PAGES
20

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL