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

Forrest G. Hall and Karl Huemmrich, Editors

Volume 203

BOREAS TF-8 NSA-OJP Tower Flux, Meteorological, and Soil Temperature Data

Kathleen E. Moore and David R. Fitzjarrald
State University of New York, Albany

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

November 2000

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BOREAS TF-8 NSA-OJP Tower Flux, Meteorological, and Soil Temperature Data

Kathleen E. Moore, David R. Fitzjarrald

Summary

The BOREAS TF-8 team collected energy, CO_2, and water vapor flux data at the BOREAS NSA-OJP site during the growing season of 1994 and most of the year for 1996. The data are available in tabular ASCII files.

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1. Data Set Overview

1.1 Data Set Identification

BOREAS TF-08 NSA-OJP Tower Flux, Meteorological, and Soil Temperature Data

1.2 Data Set Introduction

This study focused on long-term measurements of radiation, heat, moisture, CO_2, and momentum budgets from the tower at the BOReal-Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA) Old Jack Pine (OJP) site. Turbulent fluxes were determined using the eddy correlation technique, and radiative fluxes in the short, long, near-infrared, and Photosynthetically Active Radiation (PAR) wavelength bands were acquired as well. Also, soil moisture content data were collected. Through collaboration with other groups, the CO_2 gradients inside and just above the canopy were acquired. In addition, a digital cloud camera was used to obtain a seasonal record of cloud fraction and cloud type.

1.3 Objective/Purpose

The objective was to make measurements of the components of the energy and radiation balances over an old jack pine forest in the Canadian boreal forest ecosystem during a period of time encompassing a large portion of a growing season. These measurements, together with direct measurements of the CO_2 flux, provide a view of ecosystem functioning on a wide range of time scales. In addition, the contribution of jack pine landcover to the regional fluxes of heat, water vapor, momentum, and CO_2 was assessed.

1.4 Summary of Parameters

Turbulent flux measurements included above- and below-canopy measurements of sensible and latent heat fluxes, CO_2 flux, and friction velocity. Gradient measurements included vertical profiles of wind speed, relative and specific humidity, and air temperature. Radiative measurements included net radiation, upwelling and downwelling PAR, upwelling and downwelling global shortwave radiation, upwelling and downwelling longwave radiation, surface temperature, and undercanopy net radiation. Meteorological measurements included wind speed and direction, air pressure, and rainfall. Soil measurements included soil water potential, soil temperature, and soil heat flux. These measurements were collected at different locations with different ground covers. The soil temperatures were collected at multiple depths.

1.5 Discussion

The objectives of this study were to obtain the time series of the elements in the surface energy and water balance during the growing season at the BOREAS NSA-OJP in order to provide data to investigate vegetation-atmosphere models; to relate the vertical wind profile to the frequency and type of coherent turbulent eddies in the canopy layer; and to relate components of radiation budget, the observed cloud fraction, type, and height to develop feedback relationships between surface heat and water vapor fluxes and convective cloud cover.

By making redundant measurements of the components of the energy balance, uncertainty is reduced and the possibility of discovering the true balance is increased. Gradient measurements are of interest in their own right, for instance, to obtain estimates of the displacement height. Each measurement has its own footprint. For example, the sonic anemometer at tower top is looking at an area perhaps 200-500 m upwind of the sensor, while the net radiometer is measuring a smaller area closer to the tower.

1.6 Related Data Sets

BOREAS TF-05 SSA-OJP Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-03 NSA-OBS Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-08 NSA-OJP and SSA-OBS Ceilometer Data
BOREAS TF-10 NSA-YJP Tower Flux, Meteorological, and Biophysical Data
BOREAS TF-10 NSA-Fen Tower Flux and Meteorological Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

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Atmospheric Sciences Research Center (ASRC)

Kathleen E. Moore
Research Scientist
ASRC

2.2 Title of Investigation

Surface Exchange Observations in the Canadian Boreal Forest Region

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3. Theory of Measurements

The boreal forest is important to the global energy and carbon balance, due partly to the large area covered by this vegetation type. Measurements on a wide variety of time and space scales are required in order to achieve an integrated understanding of these balances and the factors that affect them from day to day and over a growing season. Tower-based measurements provide ground truth for satellite and other remote sensing measurements. Eddy correlation estimates represent the only direct measurements of fluxes. Auxiliary measurements, e.g., soil, gradients, etc., are of fundamental importance. For example, it may be possible to use a similarity argument for water vapor and CO_2 to get the CO_2 storage term at night by examining how humidity builds up in the stable surface layer.

Eddy correlation measurements are accomplished by simply calculating the covariance between the fluctuating vertical velocity and the fluctuating scalar or vector quantity of interest.

4. Equipment

4.1 Sensor/Instrument Description

4.1.1 Collection Environment

Measurements were collected from late May through mid-September 1994 and mid-April through mid-November of 1996. Over that time period, temperature conditions from less than -15 °C to over 30 °C were experienced.

4.1.2 Source/Platform

A 30-m Rohn communications tower was used throughout the experiment. Turbulent fluxes were measured at the top of the tower and at 13 m (until 29-Jul-1994, when a separate, 2-m mast was erected for subcanopy fluxes). In 1994, the subcanopy flux measurements were made in an open, lichen-covered area approximately 15 m west of the tall tower. In 1996, the subcanopy array was erected on 09-Jul in a moss-covered area to the north of the tower.

4.1.3 Source/Platform Mission Objectives

The purpose of the tower was to support instruments to measure energy, water, and CO_2 fluxes and related environmental variables above and within an old jack pine forest.

4.1.4 Key Variables

Turbulent flux measurements included above- and below-canopy measurements of sensible and latent heat fluxes, CO_2 flux, and friction velocity.

Gradient measurements included vertical profiles of wind speed, relative and specific humidity, and air temperature.

Radiative measurements included net radiation, upwelling and downwelling PAR, upwelling and downwelling global shortwave radiation, upwelling and downwelling longwave radiation, surface temperature, and undercanopy net radiation.

Meteorological measurements included wind speed and direction, air pressure, and rainfall.

Soil measurements included soil water potential, soil temperature, and soil heat flux. These measurements were collected at different locations with different ground covers. The soil temperatures were collected at multiple depths.

4.1.5 Principles of Operation

Eddy correlation variables were acquired at a 10-Hz rate. Serial output from the 3-axis and 1-axis sonic anemometers was collected directly at serial ports in a Sun workstation. In 1994, the 3-axis anemometer was set up to receive a strobe signal from a Harrison datalogger in order to synchronize the sonic measurements with the scalar eddy quantities (e.g., water vapor and CO_2). The same Harrison datalogger received the analog signals of the scalars and performed the analog to digital conversion. These data were passed to the Sun in a separate serial stream.

A fourth serial stream contained data from the slower response radiation and gradient measurements, converted to digital form by a separate Harrison datalogger. Acquisition for this group of signals was at 0.02 Hz. A custom digital counter board kept count of the cup anemometer rotations; the datalogger read these at a 40-Hz rate and reset the counters every 5 seconds.

In 1994, analog signals from the upper sonic (3-axis) anemometer were also acquired by the Harrison logger.

In 1996, only analog signals from the sonic anemometers were acquired.

Campbell Scientific 21x dataloggers were used as backup acquisition systems for the radiation, gradient, and flux (upper level) systems. A separate Campbell Scientific 21x datalogger was dedicated to the soil measurements. Two Campbell Scientific 21x dataloggers were assigned as backup acquisition systems for the Harrison loggers.

4.1.6 Sensor/Instrument Measurement Geometry

Sonic anemometers were mounted at heights of 30 m and 13 m above ground level. Temperature and humidity gradient measurements were collected at 22.68-m, 15.65-m, 9.32-m, and 4.22-m heights. Wind speed gradient measurements were collected at 18.88-m, 14.65-m, 11.32-m, 9.32-m, 6.35-m, and 1.92-m heights. Radiation measurements, including net radiation, incident and reflected global shortwave radiation, incident and reflected global longwave radiation, incident and reflected PAR, and the temperatures of the upwelling and downwelling longwave radiation were measured at 27-m height. Subcanopy measurements of net radiation were collected at 1-m height in an open lichen covered area, and at 1.5-m in an area under a closed canopy.

In 1994, soil temperature profiles were taken at three locations: a lichen-covered area between two jack pines, a moss-covered area under the jack pine canopy, and an area covered with a mixture of moss and lichen. At the lichen-covered site, soil temperatures were collected at 2.5-cm, 7.5-cm, and 20-cm depths. At the moss-covered site soil temperatures were collected at 2.5-cm, 10-cm, and 22.5-cm depths. At the mixed site, soil temperatures were collected at 2.5-cm, 7.5-cm, and 20-cm depths. At all three sites, soil heat flux was measured at 4-cm depth and soil water potential was measured using gypsum soil moisture blocks at the lichen- and moss-covered areas at a depth of 8-cm. In 1996, there were three sites for soil measurements: a closed site, a semiclosed site, and an open site. At the closed site, soil temperature measurements were collected at 6.4-cm, 14-cm, and 26.7-cm depths. At both the semiclosed and open sites, soil temperature data were collected at 2.5-cm, 10.2-cm, and 22.8-cm depths. Soil heat fluxes were measured at 10.2-cm depth at the closed site, and at 6.4-cm depth at the semiclosed and open sites.

In 1994, three different rainfall measurements were collected. One measurement was made from a 3-m trough (vinyl rain gutter) under the jack pine canopy using an MRI tipping bucket rain gauge. The collecting area for this gauge was expanded 9 times by using the trough. A second rain gauge was located at 0.5-m height in the opening between jack pine trees. A third rainfall measurement was collected from a gauge located at 15 m on the flux tower. These other two rain gauges were both Campbell Scientific model TE525. In 1996, rainfall data were collected from the trough and tower rain gauges.

4.1.7 Manufacturer of Sensor/Instrument

3-axis and 1-axis sonic anemometers:
Applied Technologies, Inc.
1120 Delaware Ave.
Longmont, CO 80501
(303) 684-8722
(303) 684-8773 (fax)
sales@apptech.com

Kipp and Zonen CG-2(net longwave) and CM14 (albedometer):
Kipp & Zonen
P.O. Box 507
2600AM Delft
The Netherlands
+31 15 269 8000
+31 15 262 0351 (fax)

LI-COR LI-190SA PAR sensors, LI6262 CO2,H2O instrument:
LI-COR, Inc.
4421 Superior Street
P.O. Box 4425
Lincoln, NE 68504
(402) 467-3576

Swissteco type S-1 Net Pyradiometer:
Swissteco Pty., Ltd.
Melbourne, Victoria
Australia 31.

Campbell Scientific Krypton hygrometers, soil temperature model 107, soil heat flux model HFT-1:
Campbell Scientific, Inc.
815 West 1800 North
Logan, UT 84321-1784
(435) 753-2342
(435) 750-9540 (fax)
info@campbellsci.com

Vaisala air temperature and relative humidity probes. Temperature measured with AD590 IC temperature transducer, relative humidity probe was humi-cap resistance device:
Vaisala, Inc.
U.S. Office
100 Commerce Way
Woburn, MA 01801-1068
(781) 933-4500

Gill propeller-vane anemometer:
Gill Instruments Limited
Solent House
Cannon Street
Lymington, Hampshire
SO41 9BR
UK
+44 (0)1590 679955
+44 (0)1590 676409 (fax)

Met One model 014A cup wind speed sensor and radiation shield (with fan):
Met One Instruments, Inc.
1600 Washington Blvd.
Grants Pass, OR 97526
(541) 471-7111
(541) 471-7116 (fax)

4.2 Calibration

4.2.1 Specifications

Kipp and Zonen albedometer and pyrgeometer used factory calibration. The pyrgeometer was also factory calibrated on 13-Nov-1995.

The upwelling and downwelling longwave temperature represent temperatures for the two thermopiles, measured with PT-100 devices. Following the 1993 Intensive Field Campaign (IFC), a laboratory calibration was done on these instruments, and corrections were determined and applied to the data in postprocessing. Similar tests were run following the 1996 field season. Net Radiometer comparisons with sum of components was done continuously. The two subcanopy net radiometers were compared with the above-canopy instrument in the spring of 1993 at the Atmospheric Sciences Research Center (ASRC).

The air temperature and relative humidity probes were laboratory calibrated after the 1993 IFC. Corrections have been applied to the archived data.

The CO_2 instrument was field calibrated using 1% CO_2 in air. Zero and span calibrations were carried out prior to each field season. The instrument was sent for overhaul and factory recalibration after the 1994 field season.

Krypton hygrometers were calibrated at the factory in 1993 and 1995. In postprocessing, regressions of the natural log of the voltage on the water vapor density determined from the air temperature and relative humidity probes were done. These daily, "field" regressions were used in place of the factory calibration for the upper Krypton hygrometer in 1994, and for both Krypton hygrometers in 1996.

The LI-COR water vapor instrument was calibrated at the factory before each field season. "Field calibrations" (regression of output against actual field water vapor density measurements) as described above for the Krypton hygrometers were used to convert voltages to water vapor density.

4.2.1.1 Tolerance

Applied Technologies 3-axis and 1-axis sonic anemometers:
Sensitivity: u, v, and w wind speeds: 0.01 m/s
Accuracy: wind speed ± 1%; wind direction ± 0.1°
Response time: <0.1 s

Kipp and Zonen CG-2(net longwave) and CM14 (albedometer):
Sensitivity: shortwave measurements: approximately 4 µV/(W/m^2); longwave Measurements: approximately 10 µV/(W/m^2)
Accuracy: within 1%
Response time: 30 s

LI-COR LI-190SA PAR sensors:
Sensitivity: 8 µA/(1000 µmol/s/m^2)
Accuracy: ± 5%
Response time: 10 µs

Swissteco type S-1 Net Pyradiometer:
Sensitivity: 0.48 mV/(mW cm^2)
Accuracy: ± 2.5%
Response time: 30s

LI-COR LI6262 CO_2, H_2O instrument (fast response option). Air was drawn down 3/8" Teflon tubing by a 30-liters per minute (lpm) pump. The sensor was placed in a side stream drawn off with a 10-lpm pump. A flow controller was placed in the stream going to the sensor to limit the flow through the sensor to 1 lpm, in 1994, or 2 lpm in 1996.
Sensitivity: 0.1-0.5 ppm/mv
Response time: < 0.5 s

Campbell Scientific Krypton hygrometers:
Sensitivity: 105 mV/gm^3
Response time: 0.1 s

Vaisala air temperature and relative humidity probes were installed in Met One radiation shields (with fans). Temperature was measured with AD590 IC temperature transducers, fed into a custom circuit, and calibrated in the lab in mineral oil in a precision temperature bath. Relative humidity probes were humi-cap resistance devices.
Sensitivity: Temperature - 0.01 °C /mV; Relative humidity (RH) 0.1% RH/mV
Accuracy: Temperature ± 0.01 °C; Relative humidity 3%
Response time: Temperature (AD590) 10 s; Relative humidity 15 s

Soil thermistors: Campbell Scientific 107 temperature probes.
Accuracy: 0.2 °C
Response time: 10 s

A Gill propeller-vane anemometer was mounted on the tower at 25.7. At the six remaining lower heights, Met-one model 014A cup wind speed sensors were used:
Threshold: cups: 0.5 m/s; Gill: 0.1-0.2 m/s
Accuracy: cups: ± 1.5%; Gill: unknown
Distance constant: cups: 4.6 m; Gill: 1 m (speed), 1.2 m (direction)

Rain gauge: Campbell Scientific model TE525
Precision: 0.1 mm

Rain gauge: MRI tipping bucket:
Precision: 0.256 mm
Total area collected: 0.290 m^2

4.2.2 Frequency of Calibration

See Section 4.2.1.

4.2.3 Other Calibration Information

Webb corrections were applied to vapor density fluxes, to account for effect of density fluctuations on flux estimates (Webb et al., 1980). The effect of water vapor flux on the heat capacity of air was also accounted for in the conversion from kinematic heat flux to W/m^2. The effect of oxygen absorption in the ultraviolet (UV) was corrected for in calculating water vapor flux from the krypton hygrometer (Campbell and Tanner, 1985).

The air temperature and relative humidity probes were laboratory calibrated after the 1993 IFC. The laboratory calibration yielded these corrections:

```
T_22.7m = 0.01013*(mv) + 0.00075
T_15.7m = 0.0103*(mv)  + 0.00257
T_9.3m  = 0.0101*(mv)  + 0.00278
T_4.2m  = 0.01001*(mv) + 0.00125
```

The air temperature variables are represented in the form where T_22.7m is the air temperature at 22.7 m height, and mv is the instrument output in millivolts.

5. Data Acquisition Methods

Eddy correlation variables were acquired at a 10-Hz rate. Serial output from the 3-axis and 1-axis sonic anemometers was collected directly at serial ports in a Sun workstation. In 1994, the 3-axis anemometer was set up to receive a strobe signal from a Harrison datalogger in order to synchronize the sonic measurements with the scalar eddy quantities (e.g., water vapor and CO_2). The same Harrison datalogger received the analog signals of the scalars and performed the analog to digital conversion. These data were passed to the Sun in a separate serial stream.

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A sky imaging system was located on the roof of the hut. In 1993 and 1994, the imaging system consisted of one charged coupled device (CCD) with image acquisition hardware and software. This system used fish-eye and 28-mm lenses and produced digitized images with 256 by 244 pixels and 64 gray scales. In 1996, video images were digitized in 24-bit color using joint photographic experts group (jpg) format, with 751 by 484 pixels and 256 levels each of red, green, and blue.

6. Observations

6.1 Data Notes

Gaps in the data in all years occur due to instrument failure or computer failure.

6.2 Field Notes

Field notes are contained in four notebooks located at ASRC in Albany.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

All data were collected at the BOREAS NSA-OJP site. The North American Datum of 1983 (NAD83) coordinates for the NSA-OJP tower were latitude 55.92842° N, longitude 98.62396° W, and elevation of 255.1 m.

Turbulent fluxes were measured at the top of the flux tower, and at 13 m high on the flux tower, until 29-Jul-1994, when a separate 2-m-tall mast was erected for subcanopy fluxes. In 1994, the subcanopy flux measurements were made in an open, lichen-covered area approximately 15 m west of the main tower. In 1996, the subcanopy array was erected on 09-Jul in a moss-covered area to the north of the tower.

Soil temperature and heat flux measurements were made at three sites chosen for their microsite variation (mossy cover, lichen cover, and intermediate). These sites were all 30-40 m from the flux tower in the northwest direction.

The sky camera was placed on the roof of the shack at the site. The ceilometer was located on the tent platform to the south of the shack.

Subcanopy net radiation measurements in 1994 were made in an open area and an area of denser canopy, to the north of the flux tower. One rain gauge was located on the flux tower at 15 m, one was in the subcanopy layer in an opening, and a third collected rain from a trough 10 feet long under closed canopy.

7.1.2 Spatial Coverage Map

Not applicable.

7.1.3 Spatial Resolution

Data collected from flux towers are often thought of as point data. However, particularly in terms of the eddy flux data, they actually represent an integrated upwind source region. The size of the region being sampled is related to factors such as the height of the tower, the roughness of the canopy, and the wind speed.

7.1.4 Projection

None.

7.1.5 Grid Description

None.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
Data collection in 1993 covered the following dates:

- Turbulent fluxes: 11-Aug to 29-Aug-1993
- Soil measurements: 11-Aug to 29-Aug-1993
- Water vapor flux: 20-Aug to 29-Aug-1993
- CO_2 flux : 23-Aug to 29-Aug-1993
- Radiative fluxes: 14-Aug to 29-Aug-1993
- Gradient measurements: 14-Aug to 29-Aug-1993
- Sky camera images: 17-Aug to 29-Aug-1993

Data collection in 1994 covered the following dates:

- Turbulent fluxes: 24-May to 19-Sep-1994
- Second level fluxes moved from 13 m to 2 m on 29-Jul-1994
- Soil measurements: 28-May to 19-Sep-1994
- Radiative fluxes: 24-May to 19-Sep-1994
- Gradient measurements: 24-May to19-Sep-1994
- Sky camera images: 01-Jun to 19-Sep-1994
- Ceilometer measurements: 28-May 28 to 17-Sep-1994

Data collection in 1996 covered the following dates:

- Turbulent fluxes: 15-Apr to 09-Nov-1996
- Second level fluxes: 19-Jul to 09-Nov-1996
- Second level CO_2 flux: 26-Sep to 09-Nov-1996
- Soil measurements: 25-May to 09-Nov-1996
- Radiative fluxes: 15-Apr to 09-Nov-1996
- IR thermometers: 20-Jul to 09-Nov-1996
- Gradient measurements: 15-Apr to 09-Nov-1996
- Sky camera images: 06-May to 09-Nov-1996
- Ceilometer measurements: 29-May to 09-Nov-1996

7.2.2 Temporal Coverage Map
None.

7.2.3 Temporal Resolution
The 1996 data were averaged over 30-minute periods. The 1993 and 1994 data were averaged over 20-minute periods. These data were then interpolated to 30-minute time periods.

7.3 Data Characteristics

7.3.1 Parameter/Variable
The parameters contained in the data files on the CD-ROM are:

```
         Column Name
------------------------------
SITE_NAME
SUB_SITE
DATE_OBS
TIME_OBS
SENSIBLE_HEAT_FLUX_ABV_CNPY
LIC_LATENT_HEAT_FLUX_ABV_CNPY
LATENT_HEAT_FLUX_ABV_CNPY
NET_RAD_ABV_CNPY
```

CO2_FLUX_ABV_CNPY
DOWN_PPFD_ABV_CNPY
UP_PPFD_ABV_CNPY
WIND_SPEED_192CM
WIND_SPEED_635CM
WIND_SPEED_932CM
WIND_SPEED_1132CM
WIND_SPEED_1465CM
WIND_SPEED_ABV_CNPY
GILL_WIND_SPEED_ABV_CNPY
WIND_DIR_ABV_CNPY
FRICTION_VEL_ABV_CNPY
AIR_TEMP_ABV_CNPY
SOIL_HEAT_FLUX_CLOSED_102MM
SOIL_HEAT_FLUX_SEMI_CLOSE_64MM
SOIL_HEAT_FLUX_OPEN_64MM
SOIL_HEAT_FLUX_MOSS_40MM
SOIL_HEAT_FLUX_LICH_MOSS_40MM
SOIL_HEAT_FLUX_LICHEN_40MM
SOIL_TEMP_LICH_MOSS_25MM
SOIL_TEMP_LICH_MOSS_75MM
SOIL_TEMP_LICH_MOSS_200MM
SOIL_TEMP_MOSS_25MM
SOIL_TEMP_MOSS_100MM
SOIL_TEMP_MOSS_225MM
SOIL_TEMP_LICHEN_25MM
SOIL_TEMP_LICHEN_75MM
SOIL_TEMP_LICHEN_200MM
SOIL_TEMP_CLOSED_64MM
SOIL_TEMP_CLOSED_140MM
SOIL_TEMP_CLOSED_267MM
SOIL_TEMP_SEMI_CLOSED_25MM
SOIL_TEMP_SEMI_CLOSED_102MM
SOIL_TEMP_SEMI_CLOSED_229MM
SOIL_TEMP_OPEN_25MM
SOIL_TEMP_OPEN_102MM
SOIL_TEMP_OPEN_229MM
SOIL_WATER_POT_LICHEN_8CM
SOIL_WATER_POT_MOSS_8CM
RAINFALL_ABV_CNPY
RAINFALL_BELOW_CNPY
TROUGH_RAINFALL
DOWN_SOLAR_RAD_ABV_CNPY
UP_SOLAR_RAD_ABV_CNPY
AIR_TEMP_422CM
AIR_TEMP_932CM
AIR_TEMP_1565CM
SURF_PRESS
DOWN_LONGWAVE_RAD_ABV_CNPY
UP_LONGWAVE_RAD_ABV_CNPY
UP_LONGWAVE_RAD_SENSOR_TEMP
DOWN_LONGWAVE_RAD_SENSOR_TEMP
LONG_PLUS_SHORT_RAD_ABV_CNPY
SURF_TEMP_ABV_CNPY

SPECIFIC_HUM_422CM
SPECIFIC_HUM_932CM
SPECIFIC_HUM_1565CM
SPECIFIC_HUM_ABV_CNPY
REL_HUM_422CM
REL_HUM_932CM
REL_HUM_1565CM
REL_HUM_ABV_CNPY
SENSIBLE_HEAT_FLUX_BELOW_CNPY
LATENT_HEAT_FLUX_BELOW_CNPY
CO2_FLUX_BELOW_CNPY
NET_RAD_OPEN_100CM
NET_RAD_BELOW_CNPY
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:

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) of the start of the data collection.
SENSIBLE_HEAT_FLUX_ABV_CNPY	The sensible heat flux measured above the canopy.
LIC_LATENT_HEAT_FLUX_ABV_CNPY	The latent heat flux measured above the canopy using a LI-COR instrument.
LATENT_HEAT_FLUX_ABV_CNPY	The latent heat flux measured above the canopy.
NET_RAD_ABV_CNPY	The net radiation measured above the canopy.
CO2_FLUX_ABV_CNPY	The carbon dioxide flux measured above the canopy.
DOWN_PPFD_ABV_CNPY	The downward (incoming) photosynthetic photon flux density measured above the canopy.
UP_PPFD_ABV_CNPY	The reflected photosynthetic photon flux density measured above the canopy.
WIND_SPEED_192CM	The wind speed measured 1.92 m above the ground.
WIND_SPEED_635CM	The wind speed measured 6.35 m above the ground.
WIND_SPEED_932CM	The wind speed measured 9.32 m above the ground.
WIND_SPEED_1132CM	The wind speed measured 11.32 m above the ground.
WIND_SPEED_1465CM	The wind speed measured 14.65 m above the ground.
WIND_SPEED_ABV_CNPY	The wind speed measured above the canopy. In

	this case at 18.88 m above the ground.
GILL_WIND_SPEED_ABV_CNPY	The wind speed measured above the canopy with the Gill anemometer at 25.7 m above the ground.
WIND_DIR_ABV_CNPY	The direction from which the wind is blowing (in creasing in a clockwise direction from the North) and measured above the canopy at 25.7 m above the ground.
FRICTION_VEL_ABV_CNPY	The friction velocity above the canopy.
AIR_TEMP_ABV_CNPY	The air temperature measured above the canopy.
SOIL_HEAT_FLUX_CLOSED_102MM	The soil heat flux measured at 10.16 cm depth at a site under closed canopy.
SOIL_HEAT_FLUX_SEMI_CLOSE_64MM	The soil heat flux measured at 6.35 cm depth at a site under a semi-closed canopy.
SOIL_HEAT_FLUX_OPEN_64MM	The soil heat flux measured at 6.35 cm depth at an open site.
SOIL_HEAT_FLUX_MOSS_40MM	The soil heat flux measured at 4 cm depth at a moss covered site.
SOIL_HEAT_FLUX_LICH_MOSS_40MM	The soil heat flux measured at 4 cm depth at a lichen and moss covered site.
SOIL_HEAT_FLUX_LICHEN_40MM	The soil heat flux measured at 4 cm depth at a lichen covered site.
SOIL_TEMP_LICH_MOSS_25MM	Soil temperature at 2.5 cm depth at a lichen and moss covered site.
SOIL_TEMP_LICH_MOSS_75MM	Soil temperature at 7.5 cm depth at a lichen and moss covered site.
SOIL_TEMP_LICH_MOSS_200MM	Soil temperature at 20 cm depth at a lichen and moss covered site.
SOIL_TEMP_MOSS_25MM	Soil temperature at 2.5 cm depth at a moss Covered site.
SOIL_TEMP_MOSS_100MM	Soil temperature at 10 cm depth at a moss covered site.
SOIL_TEMP_MOSS_225MM	Soil temperature at 22.5 cm depth at a moss covered site.
SOIL_TEMP_LICHEN_25MM	Soil temperature at 2.5 cm depth at a lichen covered site.
SOIL_TEMP_LICHEN_75MM	Soil temperature at 7.5 cm depth at a lichen covered site.
SOIL_TEMP_LICHEN_200MM	Soil temperature at 20 cm depth at a lichen covered site.
SOIL_TEMP_CLOSED_64MM	Soil temperature at 6.4 cm depth at a site under closed canopy.
SOIL_TEMP_CLOSED_140MM	Soil temperature at 13.97 cm depth at a site under closed canopy.
SOIL_TEMP_CLOSED_267MM	Soil temperature at 26.67 cm depth at a site under closed canopy.
SOIL_TEMP_SEMI_CLOSED_25MM	Soil temperature at 2.54 cm depth at a site under a semi-closed canopy.
SOIL_TEMP_SEMI_CLOSED_102MM	Soil temperature at 10.16 cm depth at a site under a semi-closed canopy.
SOIL_TEMP_SEMI_CLOSED_229MM	Soil temperature at 22.86 cm depth at a site under a semi-closed canopy.
SOIL_TEMP_OPEN_25MM	Soil temperature at 2.54 cm depth at an open site.
SOIL_TEMP_OPEN_102MM	Soil temperature at 10.16 cm depth at an open

	site.
SOIL_TEMP_OPEN_229MM	Soil temperature at 22.86 cm depth at an open site.
SOIL_WATER_POT_LICHEN_8CM	The soil water potential at 8 cm depth at a lichen covered site.
SOIL_WATER_POT_MOSS_8CM	The soil water potential at 8 cm depth at a moss covered site.
RAINFALL_ABV_CNPY	The amount of rainfall measured above the canopy. In 1994 the measurement is over a 30 minute period, in 1996 over an hour.
RAINFALL_BELOW_CNPY	The amount of rainfall measured below the canopy in a clearing. In 1994 the measurement is over a 30 minute period, in 1996 over an hour.
TROUGH_RAINFALL	The amount of rainfall measured in a trough below the canopy, the trough area is 9 times the collection area of the other rain gauges. In 1994 the measurement is over a 30 minute period, in 1996 over an hour.
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_422CM	The air temperature measured at 4.22 meters above the ground.
AIR_TEMP_932CM	The air temperature measured at 9.32 meters above the ground.
AIR_TEMP_1565CM	The air temperature measured at 15.65 meters Above the ground.
SURF_PRESS	The atmospheric pressure measured at the station.
DOWN_LONGWAVE_RAD_ABV_CNPY	The downward (incoming) longwave radiation measured above the canopy.
UP_LONGWAVE_RAD_ABV_CNPY	The upward (outgoing) longwave radiation measured above the canopy.
UP_LONGWAVE_RAD_SENSOR_TEMP	The temperature of the sensor measuring the upward longwave radiation.
DOWN_LONGWAVE_RAD_SENSOR_TEMP	The temperature of the sensor measuring the downward longwave radiation.
LONG_PLUS_SHORT_RAD_ABV_CNPY	The sum of the longwave and shortwave radiation measurements.
SURF_TEMP_ABV_CNPY	The surface radiation temperature measured from above the canopy.
SPECIFIC_HUM_422CM	The specific humidity measured at 4.22 meters above the ground.
SPECIFIC_HUM_932CM	The specific humidity measured at 9.32 meters above the ground.
SPECIFIC_HUM_1565CM	The specific humidity measured at 15.65 meters above the ground.
SPECIFIC_HUM_ABV_CNPY	The specific humidity measured above the canopy.
REL_HUM_422CM	The relative humidity measured at 4.22 meters above the ground.
REL_HUM_932CM	The relative humidity measured at 9.32 meters above the ground.
REL_HUM_1565CM	The relative humidity measured at 15.65 meters above the ground.

REL_HUM_ABV_CNPY	The relative humidity measured above the canopy.
SENSIBLE_HEAT_FLUX_BELOW_CNPY	The sensible heat flux measured below the canopy.
LATENT_HEAT_FLUX_BELOW_CNPY	The latent heat flux measured below the canopy.
CO2_FLUX_BELOW_CNPY	The carbon dioxide flux measured below the canopy.
NET_RAD_OPEN_100CM	The net radiation measured at 1 meter in canopy opening.
NET_RAD_BELOW_CNPY	The net radiation measured below the canopy.
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:

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
SENSIBLE_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
LIC_LATENT_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
LATENT_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
NET_RAD_ABV_CNPY	[Watts][meter^-2]
CO2_FLUX_ABV_CNPY	[micromoles][meter^-2][second^-1]
DOWN_PPFD_ABV_CNPY	[micromoles][meter^-2][second^-1]
UP_PPFD_ABV_CNPY	[micromoles][meter^-2][second^-1]
WIND_SPEED_192CM	[meters][second^-1]
WIND_SPEED_635CM	[meters][second^-1]
WIND_SPEED_932CM	[meters][second^-1]
WIND_SPEED_1132CM	[meters][second^-1]
WIND_SPEED_1465CM	[meters][second^-1]
WIND_SPEED_ABV_CNPY	[meters][second^-1]
GILL_WIND_SPEED_ABV_CNPY	[meters][second^-1]
WIND_DIR_ABV_CNPY	[degrees]
FRICTION_VEL_ABV_CNPY	[meters][second^-1]
AIR_TEMP_ABV_CNPY	[degrees Celsius]
SOIL_HEAT_FLUX_CLOSED_102MM	[Watts][meter^-2]
SOIL_HEAT_FLUX_SEMI_CLOSE_64MM	[Watts][meter^-2]
SOIL_HEAT_FLUX_OPEN_64MM	[Watts][meter^-2]
SOIL_HEAT_FLUX_MOSS_40MM	[Watts][meter^-2]
SOIL_HEAT_FLUX_LICH_MOSS_40MM	[Watts][meter^-2]
SOIL_HEAT_FLUX_LICHEN_40MM	[Watts][meter^-2]
SOIL_TEMP_LICH_MOSS_25MM	[degrees Celsius]
SOIL_TEMP_LICH_MOSS_75MM	[degrees Celsius]
SOIL_TEMP_LICH_MOSS_200MM	[degrees Celsius]
SOIL_TEMP_MOSS_25MM	[degrees Celsius]
SOIL_TEMP_MOSS_100MM	[degrees Celsius]
SOIL_TEMP_MOSS_225MM	[degrees Celsius]
SOIL_TEMP_LICHEN_25MM	[degrees Celsius]

SOIL_TEMP_LICHEN_75MM	[degrees Celsius]
SOIL_TEMP_LICHEN_200MM	[degrees Celsius]
SOIL_TEMP_CLOSED_64MM	[degrees Celsius]
SOIL_TEMP_CLOSED_140MM	[degrees Celsius]
SOIL_TEMP_CLOSED_267MM	[degrees Celsius]
SOIL_TEMP_SEMI_CLOSED_25MM	[degrees Celsius]
SOIL_TEMP_SEMI_CLOSED_102MM	[degrees Celsius]
SOIL_TEMP_SEMI_CLOSED_229MM	[degrees Celsius]
SOIL_TEMP_OPEN_25MM	[degrees Celsius]
SOIL_TEMP_OPEN_102MM	[degrees Celsius]
SOIL_TEMP_OPEN_229MM	[degrees Celsius]
SOIL_WATER_POT_LICHEN_8CM	[megaPascals]
SOIL_WATER_POT_MOSS_8CM	[megaPascals]
RAINFALL_ABV_CNPY	[millimeters]
RAINFALL_BELOW_CNPY	[millimeters]
TROUGH_RAINFALL	[millimeters]
DOWN_SOLAR_RAD_ABV_CNPY	[Watts][meter^-2]
UP_SOLAR_RAD_ABV_CNPY	[Watts][meter^-2]
AIR_TEMP_422CM	[degrees Celsius]
AIR_TEMP_932CM	[degrees Celsius]
AIR_TEMP_1565CM	[degrees Celsius]
SURF_PRESS	[kiloPascals]
DOWN_LONGWAVE_RAD_ABV_CNPY	[Watts][meter^-2]
UP_LONGWAVE_RAD_ABV_CNPY	[Watts][meter^-2]
UP_LONGWAVE_RAD_SENSOR_TEMP	[degrees Celsius]
DOWN_LONGWAVE_RAD_SENSOR_TEMP	[degrees Celsius]
LONG_PLUS_SHORT_RAD_ABV_CNPY	[Watts][meter^-2]
SURF_TEMP_ABV_CNPY	[degrees Celsius]
SPECIFIC_HUM_422CM	[grams][kilogram^-1]
SPECIFIC_HUM_932CM	[grams][kilogram^-1]
SPECIFIC_HUM_1565CM	[grams][kilogram^-1]
SPECIFIC_HUM_ABV_CNPY	[grams][kilogram^-1]
REL_HUM_422CM	[percent]
REL_HUM_932CM	[percent]
REL_HUM_1565CM	[percent]
REL_HUM_ABV_CNPY	[percent]
SENSIBLE_HEAT_FLUX_BELOW_CNPY	[Watts][meter^-2]
LATENT_HEAT_FLUX_BELOW_CNPY	[Watts][meter^-2]
CO2_FLUX_BELOW_CNPY	[micromoles][meters^-2][second^-1]
NET_RAD_OPEN_100CM	[Watts][meter^-2]
NET_RAD_BELOW_CNPY	[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:

Column Name	Data Source
SITE_NAME	[Assigned by BORIS.]
SUB_SITE	[Assigned by BORIS.]
DATE_OBS	[Supplied by Investigator.]
TIME_OBS	[Supplied by Investigator.]
SENSIBLE_HEAT_FLUX_ABV_CNPY	[Sonic anemometer]
LIC_LATENT_HEAT_FLUX_ABV_CNPY	[LI-COR Infrared Gas Analyzer]
LATENT_HEAT_FLUX_ABV_CNPY	[Campbell Scientific Krypton hygrometer]
NET_RAD_ABV_CNPY	[Net radiometer]
CO2_FLUX_ABV_CNPY	[Infrared Gas Analyzer]
DOWN_PPFD_ABV_CNPY	[quantum sensor]
UP_PPFD_ABV_CNPY	[quantum sensor]
WIND_SPEED_192CM	[Met-One cup anemometer]
WIND_SPEED_635CM	[Met-One cup anemometer]
WIND_SPEED_932CM	[Met-One cup anemometer]
WIND_SPEED_1132CM	[Met-One cup anemometer]
WIND_SPEED_1465CM	[Met-One cup anemometer]
WIND_SPEED_ABV_CNPY	[Met-One cup anemometer]
GILL_WIND_SPEED_ABV_CNPY	[Gill propeller-vane anemometer]
WIND_DIR_ABV_CNPY	[Gill propeller-vane anemometer]
FRICTION_VEL_ABV_CNPY	[Sonic anemometer]
AIR_TEMP_ABV_CNPY	[air temperature probe]
SOIL_HEAT_FLUX_CLOSED_102MM	[soil heat flux plate]
SOIL_HEAT_FLUX_SEMI_CLOSE_64MM	[soil heat flux plate]
SOIL_HEAT_FLUX_OPEN_64MM	[soil heat flux plate]
SOIL_HEAT_FLUX_MOSS_40MM	[soil heat flux plate]
SOIL_HEAT_FLUX_LICH_MOSS_40MM	[soil heat flux plate]
SOIL_HEAT_FLUX_LICHEN_40MM	[soil heat flux plate]
SOIL_TEMP_LICH_MOSS_25MM	[soil temperature probe]
SOIL_TEMP_LICH_MOSS_75MM	[soil temperature probe]
SOIL_TEMP_LICH_MOSS_200MM	[soil temperature probe]
SOIL_TEMP_MOSS_25MM	[soil temperature probe]
SOIL_TEMP_MOSS_100MM	[soil temperature probe]
SOIL_TEMP_MOSS_225MM	[soil temperature probe]
SOIL_TEMP_LICHEN_25MM	[soil temperature probe]
SOIL_TEMP_LICHEN_75MM	[soil temperature probe]
SOIL_TEMP_LICHEN_200MM	[soil temperature probe]
SOIL_TEMP_CLOSED_64MM	[soil temperature probe]
SOIL_TEMP_CLOSED_140MM	[soil temperature probe]
SOIL_TEMP_CLOSED_267MM	[soil temperature probe]
SOIL_TEMP_SEMI_CLOSED_25MM	[soil temperature probe]
SOIL_TEMP_SEMI_CLOSED_102MM	[soil temperature probe]
SOIL_TEMP_SEMI_CLOSED_229MM	[soil temperature probe]
SOIL_TEMP_OPEN_25MM	[soil temperature probe]
SOIL_TEMP_OPEN_102MM	[soil temperature probe]
SOIL_TEMP_OPEN_229MM	[soil temperature probe]
SOIL_WATER_POT_LICHEN_8CM	[gypsum soil moisture block]
SOIL_WATER_POT_MOSS_8CM	[gypsum soil moisture block]
RAINFALL_ABV_CNPY	[Campbell Scientific rain gauge]
RAINFALL_BELOW_CNPY	[Campbell Scientific rain gauge]

TROUGH_RAINFALL	[MRI tipping bucket rain gauge]
DOWN_SOLAR_RAD_ABV_CNPY	[albedometer]
UP_SOLAR_RAD_ABV_CNPY	[albedometer]
AIR_TEMP_422CM	[air temperature probe]
AIR_TEMP_932CM	[air temperature probe]
AIR_TEMP_1565CM	[air temperature probe]
SURF_PRESS	[barometer]
DOWN_LONGWAVE_RAD_ABV_CNPY	[pyrgeometer]
UP_LONGWAVE_RAD_ABV_CNPY	[pyrgeometer]
UP_LONGWAVE_RAD_SENSOR_TEMP	[thermopile]
DOWN_LONGWAVE_RAD_SENSOR_TEMP	[thermopile]
LONG_PLUS_SHORT_RAD_ABV_CNPY	[albedometer and pyrgeometer]
SURF_TEMP_ABV_CNPY	[IR thermometer]
SPECIFIC_HUM_422CM	[hygrometer]
SPECIFIC_HUM_932CM	[hygrometer]
SPECIFIC_HUM_1565CM	[hygrometer]
SPECIFIC_HUM_ABV_CNPY	[hygrometer]
REL_HUM_422CM	[psychrometer]
REL_HUM_932CM	[psychrometer]
REL_HUM_1565CM	[psychrometer]
REL_HUM_ABV_CNPY	[psychrometer]
SENSIBLE_HEAT_FLUX_BELOW_CNPY	[Sonic anemometer]
LATENT_HEAT_FLUX_BELOW_CNPY	[Campbell Scientific Krypton hygrometer]
CO2_FLUX_BELOW_CNPY	[Sonic anemometer]
NET_RAD_OPEN_100CM	[Net radiometer]
NET_RAD_BELOW_CNPY	[Net radiometer]
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.

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-OJP-FLXTR	NSA-OJP-FLXTR	None	None	None	None
SUB_SITE	9TF08-FLX01	9TF08-FLX01	None	None	None	None
DATE_OBS	24-MAY-94	12-NOV-96	None	None	None	None
TIME_OBS	0	2330	None	None	None	None
SENSIBLE_HEAT_FLUX_ABV_CNPY	-124.74	997.44	-999	None	None	Blank
LIC_LATENT_HEAT_FLUX_ABV_CNPY	-39.49	701.34	-999	None	None	Blank
LATENT_HEAT_FLUX_ABV_CNPY	-117.83	544.18	-999	None	None	Blank
NET_RAD_ABV_CNPY	-703.8	326.69	-999	None	None	Blank
CO2_FLUX_ABV_CNPY	-15	8.409	-999	None	None	Blank
DOWN_PPFD_ABV_CNPY	-1980	2360	None	None	None	Blank
UP_PPFD_ABV_CNPY	-1080	2410	None	None	None	Blank
WIND_SPEED_192CM	-15.07	155.73	-999	None	None	Blank
WIND_SPEED_635CM	-114.69	175.63	-999	None	None	Blank
WIND_SPEED_932CM	-92.58	191.22	-999	None	None	Blank
WIND_SPEED_1132CM	-14.86	184.76	-999	None	None	Blank

WIND_SPEED_1465CM	-115.91	44.97	-999	None	None	Blank
WIND_SPEED_ABV_CNPY	-122.6	24.04	-999	None	None	Blank
GILL_WIND_SPEED_ABV_CNPY	.03	7.19	-999	None	None	Blank
WIND_DIR_ABV_CNPY	1.14	359.18	-999	None	None	Blank
FRICTION_VEL_ABV_CNPY	0	2.626	-999	None	None	Blank
AIR_TEMP_ABV_CNPY	-18.02	40.8	-999	None	None	Blank
SOIL_HEAT_FLUX_CLOSED_102MM	-35.99	13.5	None	None	None	Blank
SOIL_HEAT_FLUX_SEMI_CLOSE_64MM	-70.7	19.8	None	None	None	Blank
SOIL_HEAT_FLUX_OPEN_64MM	-95.45	19.98	None	None	None	Blank
SOIL_HEAT_FLUX_MOSS_40MM	-4.723	40.637	-999	None	None	Blank
SOIL_HEAT_FLUX_LICH_MOSS_40MM	-516.282	108.18	-999	None	None	Blank
SOIL_HEAT_FLUX_LICHEN_40MM	-288.485	171.79	-999	None	None	Blank
SOIL_TEMP_LICH_MOSS_25MM	8.205	24.397	-999	None	None	Blank
SOIL_TEMP_LICH_MOSS_75MM	4.955	16.135	-999	None	None	Blank
SOIL_TEMP_LICH_MOSS_200MM	4.019	59.389	-999	None	None	Blank
SOIL_TEMP_MOSS_25MM	3.723	59.051	-999	None	None	Blank
SOIL_TEMP_MOSS_100MM	4.962	59.678	-999	None	None	Blank
SOIL_TEMP_MOSS_225MM	4.962	59.678	-999	None	None	Blank
SOIL_TEMP_LICHEN_25MM	6.191	46.177	-999	None	None	Blank
SOIL_TEMP_LICHEN_75MM	6.642	44.703	-999	None	None	Blank
SOIL_TEMP_LICHEN_200MM	7.133	42.94	-999	None	None	Blank
SOIL_TEMP_CLOSED_64MM	-1.25	20.06	-999	None	None	Blank
SOIL_TEMP_CLOSED_140MM	-.03	15.96	-999	None	None	Blank
SOIL_TEMP_CLOSED_267MM	.08	14.62	-999	None	None	Blank
SOIL_TEMP_SEMI_CLOSED_25MM	-3.5	24.18	-999	None	None	Blank
SOIL_TEMP_SEMI_CLOSED_102MM	-.77	16.97	-999	None	None	Blank
SOIL_TEMP_SEMI_CLOSED_229MM	-15.59	17.35	-999	None	None	Blank
SOIL_TEMP_OPEN_25MM	-.74	20.8	-999	None	None	Blank
SOIL_TEMP_OPEN_102MM	-.54	19	-999	None	None	Blank
SOIL_TEMP_OPEN_229MM	.21	18.12	-999	None	None	Blank
SOIL_WATER_POT_LICHEN_8CM	-2.4807	-.032	None	None	None	Blank
SOIL_WATER_POT_MOSS_8CM	-2.3104	-.0301	None	None	None	Blank

RAINFALL_ABV_CNPY	0	4.5	None	None	None	Blank
RAINFALL_BELOW_CNPY	0	8.2	None	None	None	Blank
TROUGH_RAINFALL	0	43.44	None	None	None	Blank
DOWN_SOLAR_RAD_ABV_CNPY	-944.88	235.38	-999	None	None	Blank
UP_SOLAR_RAD_ABV_CNPY	-471.38	804.16	-999	None	None	Blank
AIR_TEMP_422CM	-18.06	40.8	-999	None	None	Blank
AIR_TEMP_932CM	-18.21	38.49	-999	None	None	Blank
AIR_TEMP_1565CM	-18.42	41.13	-999	None	None	Blank
SURF_PRESS	95.65	997	-999	None	None	Blank
DOWN_LONGWAVE_RAD_ABV_CNPY	-530.27	-15.87	-999	None	None	Blank
UP_LONGWAVE_RAD_ABV_CNPY	-69.45	1158.79	None	None	None	Blank
DOWN_LONGWAVE_RAD_SENSOR_TEMP	-1.94	35.31	None	None	None	Blank
UP_LONGWAVE_RAD_SENSOR_TEMP	-1.81	35.62	None	None	None	Blank
LONG_PLUS_SHORT_RAD_ABV_CNPY	-750.83	545.71	None	None	None	Blank
SURF_TEMP_ABV_CNPY	-109.58	104.94	-999	None	None	Blank
SPECIFIC_HUM_422CM	-530.6	3528.7	-999	None	None	Blank
SPECIFIC_HUM_932CM	-511.74	51.16	-999	None	None	Blank
SPECIFIC_HUM_1565CM	-831.9	156.11	-999	None	None	Blank
SPECIFIC_HUM_ABV_CNPY	-482.14	49.54	-999	None	None	Blank
REL_HUM_422CM	16	203	-999	None	None	Blank
REL_HUM_932CM	10.63	175	-999	None	None	Blank
REL_HUM_1565CM	-72	156	-999	None	None	Blank
REL_HUM_ABV_CNPY	13.88	156	-999	None	None	Blank
SENSIBLE_HEAT_FLUX_BELOW_CNPY	-149.6	593.58	-999	None	None	Blank
LATENT_HEAT_FLUX_BELOW_CNPY	-84.39	509.86	-999	None	None	Blank
CO2_FLUX_BELOW_CNPY	-.227	1.591	-999	None	None	Blank
NET_RAD_OPEN_100CM	-996.95	1903.82	-999	None	None	Blank
NET_RAD_BELOW_CNPY	-998.65	1600.33	-999	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	14-JUL-99	17-AUG-99	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.

```
SITE_NAME,SUB_SITE,DATE_OBS,TIME_OBS,SENSIBLE_HEAT_FLUX_ABV_CNPY,
LIC_LATENT_HEAT_FLUX_ABV_CNPY,LATENT_HEAT_FLUX_ABV_CNPY,NET_RAD_ABV_CNPY,
CO2_FLUX_ABV_CNPY,DOWN_PPFD_ABV_CNPY,UP_PPFD_ABV_CNPY,WIND_SPEED_192CM,
WIND_SPEED_635CM,WIND_SPEED_932CM,WIND_SPEED_1132CM,WIND_SPEED_1465CM,
WIND_SPEED_ABV_CNPY,GILL_WIND_SPEED_ABV_CNPY,WIND_DIR_ABV_CNPY,
FRICTION_VEL_ABV_CNPY,AIR_TEMP_ABV_CNPY,SOIL_HEAT_FLUX_CLOSED_102MM,
SOIL_HEAT_FLUX_SEMI_CLOSE_64MM,SOIL_HEAT_FLUX_OPEN_64MM,
SOIL_HEAT_FLUX_MOSS_40MM,SOIL_HEAT_FLUX_LICH_MOSS_40MM,
SOIL_HEAT_FLUX_LICHEN_40MM,SOIL_TEMP_LICH_MOSS_25MM,SOIL_TEMP_LICH_MOSS_75MM,
SOIL_TEMP_LICH_MOSS_200MM,SOIL_TEMP_MOSS_25MM,SOIL_TEMP_MOSS_100MM,
SOIL_TEMP_MOSS_225MM,SOIL_TEMP_LICHEN_25MM,SOIL_TEMP_LICHEN_75MM,
SOIL_TEMP_LICHEN_200MM,SOIL_TEMP_CLOSED_64MM,SOIL_TEMP_CLOSED_140MM,
SOIL_TEMP_CLOSED_267MM,SOIL_TEMP_SEMI_CLOSED_25MM,SOIL_TEMP_SEMI_CLOSED_102MM,
SOIL_TEMP_SEMI_CLOSED_229MM,SOIL_TEMP_OPEN_25MM,SOIL_TEMP_OPEN_102MM,
SOIL_TEMP_OPEN_229MM,SOIL_WATER_POT_LICHEN_8CM,SOIL_WATER_POT_MOSS_8CM,
RAINFALL_ABV_CNPY,RAINFALL_BELOW_CNPY,TROUGH_RAINFALL,DOWN_SOLAR_RAD_ABV_CNPY,
UP_SOLAR_RAD_ABV_CNPY,AIR_TEMP_422CM,AIR_TEMP_932CM,AIR_TEMP_1565CM,SURF_PRESS,
DOWN_LONGWAVE_RAD_ABV_CNPY,UP_LONGWAVE_RAD_ABV_CNPY,
DOWN_LONGWAVE_RAD_SENSOR_TEMP,UP_LONGWAVE_RAD_SENSOR_TEMP,
LONG_PLUS_SHORT_RAD_ABV_CNPY,SURF_TEMP_ABV_CNPY,SPECIFIC_HUM_422CM,
SPECIFIC_HUM_932CM,SPECIFIC_HUM_1565CM,SPECIFIC_HUM_ABV_CNPY,REL_HUM_422CM,
REL_HUM_932CM,REL_HUM_1565CM,REL_HUM_ABV_CNPY,SENSIBLE_HEAT_FLUX_BELOW_CNPY,
LATENT_HEAT_FLUX_BELOW_CNPY,CO2_FLUX_BELOW_CNPY,NET_RAD_OPEN_100CM,
NET_RAD_BELOW_CNPY,CRTFCN_CODE,REVISION_DATE
'NSA-OJP-FLXTR','9TF08-FLX01',01-JUL-94,0,35.84,-1.29,43.73,-139.48,.227,
-490.0,-60.0,.57,.83,1.33,1.7,2.18,2.51,,,.004,19.68,,,,4.371,1.72,-14.666,
-999.0,10.939,10.458,10.758,11.065,11.065,13.952,13.917,13.634,,,,,,,,,,
-.152,-.2857,0.0,0.0,0.0,-254.58,40.5,20.34,20.09,19.92,97.47,-287.0,
402.39,21.58,21.72,-98.68,17.09,4.75,4.53,4.51,4.35,31.0,30.0,30.0,29.0,
54.84,45.12,,-58.08,-66.91,'CPI',14-JUL-99
'NSA-OJP-FLXTR','9TF08-FLX01',01-JUL-94,30,15.84,-.28,20.99,-56.15,.227,
-310.0,-50.0,.55,.75,1.25,1.9,2.39,2.91,,,.004,19.1,,,,3.54,.801,-14.674,
-999.0,10.833,10.545,10.676,11.089,11.089,13.885,13.93,13.722,,,,,,,,,,
-.1528,-.2879,0.0,0.0,0.0,-166.46,32.56,19.61,19.37,19.31,97.49,-271.98,
396.46,20.04,20.22,-9.42,16.01,5.28,5.1,5.02,4.86,36.0,35.0,35.0,34.0,
42.69,25.82,,-4.65,-25.11,'CPI',14-JUL-99
```

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

9.1.1 Derivation Techniques and Algorithms

Eddy correlation measurements are accomplished by simply calculating the covariance between the fluctuating vertical velocity and the fluctuating scalar or vector quantity of interest.

9.2 Data Processing Sequence

9.2.1 Processing Steps

Averages were calculated over 20-minute periods in 1993 and 1994, and over 30-minute periods in 1996. Eddy variables had a 4-minute running mean removed from them. The Sun workstation received the serial data and put a time stamp on each "chunk" of data representing 10 seconds. The four serial streams were synchronized using these time stamps. To make eddy correlation estimates of scalars, a more precise synchronization was provided by the lagged cross-correlation. This procedure was also used to provide the appropriate lag for the LI-COR CO_2 and H_2O signals, as there was a separate delay introduced by the time it took air to travel down the tubing to the sensor. Data submitted to the archive were interpolated to half-hour intervals.

Power spectra, co- and quad-spectra, and moments (up to the 4th) were calculated in real time, in the normal acquisition routine. Post-IFC calculations were redone after the 1993 field campaign. The coordinate rotation of McMillen et al. (1986) was done for the 3-axis sonic.

CO_2 fluxes were calibrated to ppm-m/s. The conversion from CO_2 flux in ppm-m/s to mg/(m^2 s) is: (1e-3*44*Pa)/(R*Tk), where Pa is the surface atmospheric pressure (kPa), R is gas constant, and Tk is the ambient air temperature (K).

In the processing of the flux data, a program read in the daily calibration data for latent heat and for CO_2 fluxes, and also made the following corrections:

- Specific heat capacity of air was corrected for effects of vapor.
- The water vapor flux from the Krypton hygrometer was corrected for oxygen absorption.
- The Webb (Webb et al., 1980) correction was applied.

Outliers were then removed from the data set. Finally, these data, which were still on the original 20-minute time base, were interpolated to the half-hour.

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

The 1996 data were averaged over 30-minute periods. The 1993 and 1994 data were averaged over 20-minute periods. These data were then interpolated to 30-minute time periods.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

The trough rain gauge values represent a direct measurement from that gauge. No correction was made to compensate for the increase of the collection area. The collecting area for this gauge was expanded 9 times by using the trough.

Theten's equation was used to calculate the mixing ratio. Pressure corrections due to different height locations on the tower were considered using hydrostatic equation. The air density was held constant at 1.212 g/m^3.

9.3.2 Calculated Variables

All of the turbulent flux values were calculated, including sensible and latent heat fluxes, CO_2 flux, and friction velocity.

9.4 Graphs and Plots

None.

10. Errors

10.1 Sources of Error

Webb corrections were applied to vapor density fluxes, to account for the effect of density fluctuations on flux estimates (Webb et al., 1980). The effect of water vapor flux on the heat capacity of air was also accounted for in the conversion from kinematic heat flux to W/m^2. The effect of oxygen absorption in the UV was corrected for in calculating water vapor flux from the krypton hygrometer (Campbell and Tanner, 1985).

10.2 Quality Assessment

None given.

10.2.1 Data Validation by Source

Net radiometer comparisons with the sum of components was done continuously.

10.2.2 Confidence Level/Accuracy Judgment

See Section 4.2.1.1.

10.2.3 Measurement Error for Parameters

See Section 4.2.1.1.

10.2.4 Additional Quality Assessments

None.

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

None given.

11.2 Known Problems with the Data

In 1994, the PAR sensors had offsets in them that can be readily identified by looking at the nighttime data. Problems with lags in the analog versus the serial-stream data in 1994 caused us to recalculate fluxes using only the analog sonic signals velocity.

11.3 Usage Guidance

All investigators are urged to contact D. Fitzjarrald or K. Moore concerning questions about data handling or instrument capability.

11.4 Other Relevant Information

None.

12. Application of the Data Set

These data are useful for the study of water, energy, and carbon exchange in a mature jack pine forest.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description

None given.

14.2 Software Access

None given.

15. Data Access

The NSA-OJP tower flux, meteorological, and soil temperature 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/.

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

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Funk, J.P. 1959. Improved polythene-shielded net radiometer. J. Sci. Inst. 36: 267-270.

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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).

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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.

Webb, E.K., G.I. Pearman, and R. Leuning. 1980. Correction of flux measurements density effects due to heat and water vapour transfer. Quart. J. R. Met. Soc. 106:85-100.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

```
ASCII   - American Standard Code for Information Interchange
ASRC    - Atmospheric Sciences Research Center
ATD     - Atmospheric Technology Division
ATI     - Applied Technologies, Inc.
BOREAS  - BOReal Ecosystem-Atmosphere Study
BORIS   - BOREAS Information System
CCD     - Charged Coupled Device
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    - Hyper-Text Markup Language
IFC     - Intensive Field Campaign
jpg     - Joint Photographic experts Group
lpm     - Liters Per Minute
NAD83   - North American Datum of 1983
NASA    - National Aeronautics and Space Administration
NCAR    - National Center for Atmospheric Research
NEP     - Net Ecosystem Productivity
NSA     - Northern Study Area
OBS     - Old Black Spruce
OJP     - Old Jack Pine
ORNL    - Oak Ridge National Laboratory
PAR     - Photosynthetically Active Radiation
ppm     - Parts Per Million
SSA     - Southern Study Area
TF      - Tower Flux
URL     - Uniform Resource Locator
UV      - Ultraviolet
YJP     - Young Jack Pine
```

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13. ABSTRACT *(Maximum 200 words)*

The BOREAS TF-8 team collected energy, CO_2, and water vapor flux data at the BOREAS NSA-OJP site during the growing season of 1994 and most of the year for 1996. The data are available in tabular ASCII files.

14. SUBJECT TERMS
BOREAS, tower flux, meteorological data, soil temperature data.

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