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

Forrest G. Hall and Karl Huemmrich, Editors

Volume 189

BOREAS TF-1 SSA-OA Tower Flux, Meteorological, and Soil Temperature Data

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T. Andrew Black, Z. Chen, Zoran Nesic

Summary

The BOREAS TF-1 team collected energy, carbon dioxide, and momentum flux data above the canopy along with meteorological and soils data at the BOREAS SSA-OA site from mid-April to the end 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-01 SSA-OA Tower Flux, Meteorological, and Soil Temperature Data

1.2 Data Set Introduction

The Tower Flux (TF)-01 team collected heat, carbon dioxide, and momentum fluxes along with meteorological, soil temperature, soil moisture, and tree bole temperature data measured from the BOREal Ecosystem-Atmosphere Study (BOREAS) Southern Study Area (SSA) Old Aspen (OA) tower. These data were collected between 01-April and 31-December-1996.

1.3 Objective/Purpose

The general objective was to study carbon dioxide and water vapor exchange between the forest and atmosphere at the SSA-OA site. Specific objectives were:

- To measure the fluxes of sensible heat, H₂O and CO₂ above the aspen stand throughout the year.
- To obtain from the CO₂ flux data estimates of gross photosynthesis and respiration.
- To determine the contribution of the hazelnut understory to net ecosystem productivity (NEP).
- To determine the effects of environmental factors on stand evapotranspiration and NEP.
- To take part in the development of procedures for scaling up component fluxes to the stand level.
- To study the processes controlling turbulent transfer of H₂O and CO₂ within the stand.
- To take part in the evaluation of methods of estimating nocturnal CO₂ in and above the stand.

1.4 Summary of Parameters

From the tower, above the canopy, the following variables were measured: latent heat flux, sensible heat flux, net radiation, CO₂ flux, CO₂ concentration, momentum flux, Bowen ratio, air temperature, wind speed and direction, friction velocity, incident and reflected photosynthetic photon flux density (PPFD), incident and reflected shortwave and longwave radiation, water vapor concentration, relative humidity, precipitation, and air pressure. Under the canopy, the following measurements were collected to describe the soil and forest: soil heat flux, soil temperature, soil water potential, soil water content, and tree bole temperatures.

1.5 Discussion

In 1993 and 1994, the TF-01 group measured fluxes under the canopy at the SSA-OA site, while the TF-02 group measured above-canopy fluxes and profiles at that site. In 1996, the TF-01 group moved its equipment to the top of the 39 meter tower to measure above-canopy fluxes; this document describes the 1996 data collection effort.

The fluxes of momentum, sensible heat, latent heat (water vapor), and carbon dioxide using the eddy correlation method were measured at 39 m height on the main flux tower beginning in April 1996. This system operated continuously through the rest of 1996. The eddy correlation system consisted of 3-dimensional sonic anemometer (model 1012R2A (Solent) Gill Instruments, Lymington, UK) with a 15 cm path length, an infrared gas (CO₂/H₂O) analyzer (IRGA) (model 6262, LI-COR, Inc., Lincoln, NE) and a krypton open-path hygrometer (model KH20, Campbell Scientific, Inc. (CSI), Logan, UT). Air was drawn at 8.0 L/min down 3.2 mm inner diameter (i.d.) sampling tubing (model Bev-a-line, Thermoplastic Processes Inc., Sterling, NJ), then through copper tubing (3 mm i.d.) coiled and sandwiched between two aluminum plates within the same housing as the analyzer, and then through the analyzer's sample cell. To prevent condensation in the sampling tubing, it was heated (2-3 °C above ambient) by passing an electric current through 20-AWG nichrome wire (about 15 ohms resistance) coiled around the exterior of the tubing. The pump (model DOA-V191-AA diaphragm pump, Gast Inc., Dayton, OH) was located down stream of the sample cell resulting in the sample cell pressure being about 22 kPa less than atmospheric pressure. The IRGA was operated in absolute mode with dry air at zero CO₂ concentration flowing through the reference cell at 25 cm³/min. The KH20 hygrometer was operated continuously to evaluate signal delay time and any attenuation resulting from the sample tubing (Leuning and King, 1992; Lee et al., 1994).

Supporting measurements included soil heat flux at the 3-cm depth measured using nine soil heat flux plates (two, model F, Middleton Instruments, Melbourne, Australia, and seven homemade, following Fuchs and Tanner (1968)) along a 20-m transect; average temperature of the surface 3 cm of the forest floor using two integrating thermometers; a soil temperature profile at depths of 2, 5, 10, 20, 50, and 100 cm (CSI direct-burial copper-constantan thermocouples); tree bole temperatures at 0.2, 4.0, 8.0, 12.0, and 15.8 cm (thermocouple wire); downward total and diffuse solar (model PSP pyranometer, The Eppley Laboratory, Inc., Newport, RI), downward longwave (Eppley model PIR pyrgeometer), and net radiation (one model S-1 net radiometer, Swissteco Instruments, Oberriet, Switzerland (belonging to University of British Columbia (UBC)) and one Middleton model CN-1 net

radiometer (belonging to Atmospheric Environment Service (AES)); PPFD (LI-COR model 190-SB quantum sensor) above the forest (at 33 m height from the ground); wind speed and direction above the overstory (model 05031 vane propeller anemometer, R.M. Young Co., Traverse City, MI); soil water content using the time-domain reflectometry (TDR) technique (Hook and Livingston, 1996) with two probes consisting of 3 stainless steel rods (3 mm diameter, 30 cm long, and 2 cm apart) were positioned horizontally at 8 cm (organic layer) and 15 cm (mineral layer) depths, five 120 cm segmented rods (two thin stainless steel strips, 1.2 cm wide and 1.5 cm apart bonded by an epoxy resin layer) were installed to measure average water content in 15 cm (0-30 cm) and 30 cm soil layers (30 - 120 cm depth); and infrared surface temperatures of the aspen and hazelnut canopies (model 4000 IR thermometer, Everest Interscience, Inc., Fullerton, CA).

1.6 Related Data Sets

BOREAS TF-01 SSA-OA Soil Characteristics Data

BOREAS TF-02 SSA-OA Tower Flux and Meteorological Data

BOREAS TF-01 Understory Flux, Meteorological, and Soil Temperature Data

BOREAS TF-09 SSA-OBS Tower Flux, Meteorological, and Soil Temperature Data

2. Investigator(s)

2.1 Investigator Name and Title

Prof. T. Andy Black
University of British Columbia
Department of Soil Science

2.2 Title of Investigation

Boreal Forest Atmosphere Interactions: Exchanges of Energy, Water Vapor and Trace Gases (SSA-OA)

2.3 Contact Information

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3. Theory of Measurements

Measurements of the fluxes of momentum, sensible heat, water vapor, and CO₂ were made with the eddy covariance technique. Velocity components, air temperature, water vapor density, and CO₂ concentration in the air were sampled rapidly, and calculations of relevant covariances were performed from these samples to obtain the fluxes. For example, the flux of CO₂ was determined as follows:

$$F_c = \overline{w'c'}$$

where w' is the departure of the vertical velocity component from its mean over the averaging interval, usually 30 minute, and c' is the departure of CO₂ concentration from its mean.

At the overstory level, three rotations in the coordinate transformation are applied to the flux data to make the lateral component (v'), vertical component (w'), and covariance ($\overline{u'v'}$) of the wind vector equal to zero. At the understory level, however, only the mean lateral wind velocity component was rotated to zero under the suspicion that nonzero mean vertical velocities are possible within the trunk space. Webb, Pearman, and Leuning (1980) (WPL) corrections were made to the water vapor and carbon dioxide fluxes measured using the closed-path LI-COR 6262 infrared gas analyzer (IRGA). Broadening correction was done, but not on-line (see Chen et al., 1998, for summary of theory).

4. Equipment

4.1 Sensor/Instrument Description

4.1.1 Collection Environment

Measurements were collected from mid-April to the end of 1996. Over that time period, temperature conditions from less than -30 °C to over 30 °C were experienced.

4.1.2 Source/Platform

A 37-m walk up scaffold main tower and a 6-m scaffold tower about 40 m from the main tower.

4.1.3 Source/Platform Mission Objectives

The objective of the flux tower was to support instrumentation for the study of the fluxes of CO₂, energy, water vapor, and momentum between the forest and atmosphere at the SSA-OA.

4.1.4 Key Variables

Variables measured using eddy covariance: CO₂ and water vapor fluxes, momentum fluxes, sensible heat fluxes, and latent heat fluxes.

Supporting meteorological variables: net radiation, downward total and diffuse solar radiation, downward longwave radiation, PPFD, wind speed, wind direction, air temperature, soil temperature, soil heat flux, soil moisture, and precipitation.

4.1.5 Principles of Operation

A sonic anemometer determines the wind speed by a pair of transducers acting alternately as transmitters and receivers, sending pulses of high frequency ultrasound between themselves. The 3-D sonic has three pairs of transducers arranged in nonparallel axes.

The LI-COR 6262 CO₂/H₂O analyzer is based on the difference in absorption of infrared radiation passing through two gas sampling cells. The reference cell is used for a gas of known CO₂ or H₂O concentration, and the sample cell is used for a gas of unknown concentration. Infrared radiation is transmitted through both cell paths, and the output of the analyzer is proportional to the difference in absorption between the two.

The principles of operation of most of the supporting instruments can be found in Pearcy et al. (1991) and Fritschen and Gay (1979).

4.1.6 Sensor/Instrument Measurement Geometry

Above-canopy sensors were supported by a vertical triangular mast mounted on top of a 37 m tall scaffold-type main tower. The sonic anemometer was mounted at a height of 39 m. Other above-canopy measurements included downward total and diffuse solar (model PSP pyranometer, The Eppley Laboratory, Inc., Newport, RI), downward longwave (Eppley model PIR pyrgeometer) and net radiation (one model S-1 net radiometer, Swissteco Instruments, Oberriet, Switzerland, and one Middleton model CN-1 net radiometer), PPFD (LI-COR model 190-SB quantum sensor) above the forest (at 33 m height from the ground), wind speed and direction above the overstory (model 05031 vane propeller anemometer, R.M. Young Co., Traverse City, MI), and infrared surface temperatures of the aspen and hazelnut canopies (model 4000 IR thermometer, Everest Interscience, Inc., Fullerton, CA).

Under-canopy measurements included soil heat flux measured at the 3 cm depth using nine soil heat flux plates (two model F, Middleton Instruments, Melbourne, Australia, and seven homemade, following Fuchs and Tanner (1968)) along a 20 m transect, average temperature of the surface 3 cm of the forest floor using two integrating thermometers, a soil temperature profile at depths of 2, 5, 10, 20, 50, and 100 cm (CSI direct-burial copper-constantan thermocouples); tree bole temperatures at 0.2, 4.0, 8.0, 12.0, and 15.8 cm into the bole (thermocouple wire); and soil water content using the time-domain reflectometry (TDR) technique (Hook and Livingston, 1996), where two probes consisting of 3 stainless steel rods (3 mm diameter, 30 cm long, and 2 cm apart) were positioned horizontally at 8-cm (organic layer) and 15 cm (mineral layer) depths, and five 120 cm segmented rods (two thin stainless steel strips, 1.2 cm wide and 1.5 cm apart, bonded by an epoxy resin layer) were installed to measure average water content in 15-cm (0-30 cm) and 30 cm soil layers (30-120 cm depth).

Tree bole temperatures were measured in aspen trees using thermocouples placed in the bole at several depths determined from the north side of the tree. The temperatures were measured at 3.12 m height for the 0.2 cm depth, 3.16 m height for the 4.0 cm depth, 3.18 m height for the 8.0 cm depth (the center of the bole), at 3.16 m height for the 12 cm depth (4 cm depth from south side), and at 3.12 m height for the 15.8 cm depth (0.2 cm depth from south side). In addition, a measurement of the hazelnut stem temperature was made at 0.7 m height and 0.2 cm depth.

4.1.7 Manufacturer of Sensor/Instrument

Solent sonic anemometer:

Gill Instruments Limited

Solent House

Cannon Street

Lymington

Hampshire

SO41 9BR

United Kingdom

DAT-310 sonic anemometer:
Kaijo-Denki Co., Ltd.
No 19.1 Chrome Kanda-Nishikicho
Chiyoda-Ku
Tokyo 101
Japan

LI-COR LI-6262 IRGA, 190-SB PPFD, and LAI-2000 PCA:
LI-COR Inc.
P.O. Box 4425/4421
Superior Street
Lincoln, NE 68504
(303) 499-1701
(303) 499-1767 (fax)

KH2O krypton hygrometer:
Campbell Scientific
P.O. Box 551
Logan, UT 84321

CN-1 net radiometer:
Middleton Instruments, Inc.
P.O. Box 442
South Melbourne
Victoria, 3205
Australia

S-1 net radiometer:
Swissteco Instruments, Inc.
Stegweg, Eichenwies, CH-94633 OBERRIET SG
Switzerland

PSP pyranometer and PIR pyrgeometer:
The Eppley Laboratory, Inc.
12 Sheffield Ave.
P.O. Box 419
Newport, RI 02840
(401) 847-1020
(401) 847-1031 (fax)

05031 vane propeller anemometer:
R.M. Young Co.
Traverse City, MI

Distributor:
Campbell Scientific
P.O. Box 551
Logan, UT 84321
(801) 753-234
(801) 752-3268

Soil temperature (burial) Campbell Thermocouple, Copper-constantan thermocouple:
Campbell Scientific
P.O. Box 551
Logan, UT 84321
(801) 753-2342
(801) 752-3268 (fax)

4000 IR thermometer:
Everest Interscience, Inc.
P.O. Box 3640
Fullerton, CA 92634-3640
(714) 992-4461

M1 dewpoint hygrometer (with D2 sensor):
General Eastern Instruments Corp.
Watertown, MA

HMP-35C Vaisala humidity sensor:
Vaisala, Inc.
Woburn, MA

Distributor:
Campbell Scientific
P.O. Box 551
Logan, UT 84321
(801) 753-2342
(801) 752-3268 (fax)

Soil heat flux plate (model F):
Middleton Instruments, Inc.
P.O. Box 442
South Melbourne
Victoria, 3205
Australia

Time domain reflectometry (TDR):
G.S. Gabel Corp.
Victoria, BC, Canada

CS105 Barometer:
Vaisala, Inc.
Woburn, MA

Distributor:
Campbell Scientific
P.O. Box 551
Logan, UT 84321
(801) 753-2342
(801) 752-3268 (fax)

TE525 Tipping-bucket rain gauge:
Texas Electronics

Distributor:
Campbell Scientific
P.O. Box 551
Logan, UT 84321
(801) 753-2342
(801) 752-3268 (fax)

Weighing rain gauge:
Belfort Instrument Co.
1600 S. Clinton Street
Baltimore, MD 21224

21x, CR10 Data logging system:
Campbell Scientific
P.O. Box 551
Logan, UT 84321
(801) 753-2342
(801) 752-3268 (fax)

TD-4X2N diaphragm pump:
Brailsford Co.
670 Milton Road
Rye, NY 10580
(914) 967-1820
(914) 967-1836 (fax)

DOA-V191-AA diaphragm pump:
Gast, Inc.
P.O. Box 97
Benton Harbor, MI
(616) 926-6171
(616) 925-8288 (fax)

Bev-a-line tube:
Thermoplastic Processes, Inc.
Sterling NS

Dekoron tubing:
Wirex Controls Ltd.
9446 McLaughlin Road N. Unit #27
Brampton, ON
Canada, L6X 4H9
(905) 459-0742
(905) 450-8216

4.2 Calibration

4.2.1 Specifications

In 1996, the eddy covariance IRGA at the 33 m height was automatically calibrated by one of the eddy covariance PCs at midnight every day. A solenoid valve was opened, permitting nitrogen gas to flow into the entrance of the sampling tube for 12 seconds. This established the voltage signals corresponding to zero CO₂ and water vapor concentrations. A second solenoid was then opened for 12 seconds, permitting dry air with 350 mmol/mol CO₂ to enter the sampling tube, thereby calibrating the analyzer. The computer changed the calibration parameters in the control program, which ensured that CO₂ concentration was accurate to within ± 1 mmol/mol.

4.2.1.1 Tolerance

See Section 4.2.1.

4.2.2 Frequency of Calibration

See Section 4.2.1.

4.2.3 Other Calibration Information

None.

5. Data Acquisition Methods

The eddy covariance system consisted of a 3-D sonic anemometer/thermometer (SOLENT 1012R2A) for detecting the three velocity components and air temperature, the latter being derived from the speed of sound following Kaimal and Gaynor (1991), an open-path H₂O krypton gas analyzer for measuring water vapor density in the air, and a closed-path dual H₂O/CO₂ IRGA (LI-COR 6262) for measuring water vapor density and CO₂ concentration in the air.

The Solent sampled the wind speed components at 20.83 Hz, and its analog-to digital converter sampled the LI-COR signals at 10 Hz. Prior to sampling, the latter signals had been passed through a passive filter with a 7 Hz cut-off frequency. Spectral analysis showed that frequencies above 1 Hz made almost no contribution to fluxes.

For the flux system, all raw data were recorded using PC systems with backup tape drives. Half-hour fluxes were calculated online. For other measurements, all those data were recorded by data loggers (model 21X, Campbell Scientific, Inc., Logan, UT), which were networked together, using the model MD-9 network interface, along with the main system. Every 3 hours, this network automatically transferred (using PC ANYWHERE software, Symantec Corp.) all data from the loggers to a network computer. This computer was accessed from our laboratory at UBC through a communication system, which comprised a modem, cellular phone, and Yagi antenna at the site, and a phone and modem in the laboratory. The Yagi antenna was mounted above the trees, and the cellular phone was housed in a thermostatically controlled box near the antenna. At midnight, the site computer compressed the previous 24 hours of half-hour flux data, called the laboratory, and in 3 minutes transferred (using Kermit file transfer software) the compressed data to the laboratory computer.

6. Observations

6.1 Data Notes

None.

6.2 Field Notes

None.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

All data were collected at the BOREAS SSA-OA site in the Prince Albert National Park (PANP). North American Datum of 1983 (NAD83) coordinates for the site are:

- SSA-OA: latitude 53.62889° N, longitude 106.19779° W, and elevation of 600.63 m.

7.1.2 Spatial Coverage Map

Not applicable.

7.1.3 Spatial Resolution

Although the eddy covariance measurement is made at one point, it is well known that the fluxes measured with this technique can represent fluxes averaged over a relatively large area. An analysis of the upwind land surface area that contributes to a scalar flux measurement, often referred to as "fetch" or "footprint," is crucial in understanding the origins of the flux and any possible influences of spatial heterogeneity. According to Blanken's (1997) results (using Schuepp et al., 1990, model), the cumulative flux at 39 m reached 80% of the total flux at an upwind distance of 1,200 m under neutral conditions, 900 m under typical daytime stability conditions, and 2,700 m under typical nighttime stability conditions. The corresponding values for the 4 m height (above the understory) were 130, 80, and 300 m. Baldocchi (1997) suggests the latter values are overestimates. . From the above results, there was adequate fetch at the OA site because the forest extended for at least 3 km in all directions.

7.1.4 Projection

None.

7.1.5 Grid Description

None.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

The flux data were collected from 20-April to 31-December-1996. The supporting meteorological data were collected from 02-February-1996 to 31-December-1996. Note that Saskatchewan Research Council (SRC) (Airborne Fluxes and Meteorology (AFM)-07) operated a MESONET site at the OA (70 m southeast of main tower) through the study period.

7.2.2 Temporal Coverage Map

None.

7.2.3 Temporal Resolution

The data reported are 30-minute statistical mean values.

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
LATENT_HEAT_FLUX_ABV_CNPY
NET_RAD_ABV_CNPY
SOIL_HEAT_FLUX_3CM_1
SOIL_HEAT_FLUX_3CM_4
SOIL_HEAT_FLUX_3CM_6
SOIL_HEAT_FLUX_3CM_7
SOIL_HEAT_FLUX_3CM_8
SOIL_HEAT_FLUX_3CM_9
SOIL_HEAT_FLUX_8CM
CO2_FLUX_ABV_CNPY
CO2_CONC_ABV_CNPY
CO2_CONC_39M
CO2_CONC_28M
CO2_CONC_22M
CO2_CONC_18M
CO2_CONC_10M
CO2_CONC_4M
CO2_CONC_2M
CO2_CONC_50CM
BOWEN_RATIO_ABV_CNPY
KINEM_MOMENT_FLUX_ABV_CNPY
DOWN_PPFD_ABV_CNPY
UP_PPFD_ABV_CNPY
WIND_DIR_ABV_CNPY
WIND_SPEED_ABV_CNPY
FRICTION_VEL_ABV_CNPY
MEAN_U_WIND_SPEED
VAR_W_WIND_SPEED
H2O_CONC_ABV_CNPY
H2O_CONC_39M
H2O_CONC_28M
H2O_CONC_22M
H2O_CONC_18M
H2O_CONC_10M
H2O_CONC_4M
H2O_CONC_2M
H2O_CONC_50CM
AIR_TEMP_ABV_CNPY
AIR_TEMP_ABV_CNPY_2
SOLENT_AIR_TEMP_ABV_CNPY
SOIL_TEMP_2CM
SOIL_TEMP_5CM
SOIL_TEMP_10CM
SOIL_TEMP_20CM
```

SOIL_TEMP_50CM
 SOIL_TEMP_100CM
 SOIL_TEMP_INT_3CM_3
 SOIL_TEMP_INT_3CM_4
 SOIL_WATER_POTENT_3CM
 SOIL_WATER_POTENT_6CM
 SOIL_WATER_POTENT_46CM
 SOIL_WATER_CONTENT_0_15CM
 SOIL_WATER_CONTENT_15_30CM
 SOIL_WATER_CONTENT_30_60CM
 SOIL_WATER_CONTENT_60_90CM
 SOIL_WATER_CONTENT_90_120CM
 REL_HUM_ABV_CNPY
 REL_HUM_ABV_CNPY_2
 BOLE_TEMP_2MM
 BOLE_TEMP_4CM
 BOLE_TEMP_8CM
 BOLE_TEMP_12CM
 BOLE_TEMP_158MM
 RAINFALL
 DOWN_SHORTWAVE_RAD_ABV_CNPY
 DOWN_SHORTWAVE_RAD_ABV_CNPY_2
 UP_SHORTWAVE_RAD_ABV_CNPY
 DOWN_LONGWAVE_RAD_ABV_CNPY
 UP_LONGWAVE_RAD_ABV_CNPY
 SURF_PRESS
 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.
LATENT_HEAT_FLUX_ABV_CNPY	The latent heat flux measured above the canopy.
NET_RAD_ABV_CNPY	The net radiation measured above the canopy.
SOIL_HEAT_FLUX_3CM_1	The soil heat flux measured at 3 cm depth at plot

SOIL_HEAT_FLUX_3CM_4	1. The soil heat flux measured at 3 cm depth at plot 4.
SOIL_HEAT_FLUX_3CM_6	6. The soil heat flux measured at 3 cm depth at plot 6.
SOIL_HEAT_FLUX_3CM_7	7. The soil heat flux measured at 3 cm depth at plot 7.
SOIL_HEAT_FLUX_3CM_8	8. The soil heat flux measured at 3 cm depth at plot 8.
SOIL_HEAT_FLUX_3CM_9	9. The soil heat flux measured at 3 cm depth at plot 9.
SOIL_HEAT_FLUX_8CM	The soil heat flux measured at 8 cm depth.
CO2_FLUX_ABV_CNPY	The carbon dioxide flux measured above the canopy.
CO2_CONC_ABV_CNPY	The carbon dioxide concentration measured above the canopy.
CO2_CONC_39M	The carbon dioxide concentration measured at 39 m above ground level.
CO2_CONC_28M	The carbon dioxide concentration measured at 28 m above ground level.
CO2_CONC_22M	The carbon dioxide concentration measured at 22 m above ground level.
CO2_CONC_18M	The carbon dioxide concentration measured at 18 m above ground level.
CO2_CONC_10M	The carbon dioxide concentration measured at 10 m above ground level.
CO2_CONC_4M	The carbon dioxide concentration measured at 4 m above ground level.
CO2_CONC_2M	The carbon dioxide concentration measured at 2 m above ground level.
CO2_CONC_50CM	The carbon dioxide concentration measured at 50 cm above the ground.
BOWEN_RATIO_ABV_CNPY	The above-canopy Bowen Ratio, defined as the sensible heat flux divided by the latent heat flux.
KINEM_MOMENT_FLUX_ABV_CNPY	Kinematic momentum flux density 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_DIR_ABV_CNPY	The direction from which the wind is blowing (increasing in a clockwise direction from the North) and measured above the canopy.
WIND_SPEED_ABV_CNPY	The wind speed measured above the canopy.
FRICTION_VEL_ABV_CNPY	The friction velocity above the canopy.
MEAN_U_WIND_SPEED	Mean of a 30 minute period of the streamwise wind speed.
VAR_W_WIND_SPEED	Variance of the vertical wind velocity.
H2O_CONC_ABV_CNPY	The water vapor concentration measured above the canopy.
H2O_CONC_39M	The water vapor concentration measured at 39 m above ground level.
H2O_CONC_28M	The water vapor concentration measured at 28 m

H2O_CONC_22M	above ground level. The water vapor concentration measured at 22 m above ground level.
H2O_CONC_18M	The water vapor concentration measured at 18 m above ground level.
H2O_CONC_10M	The water vapor concentration measured at 10 m above ground level.
H2O_CONC_4M	The water vapor concentration measured at 4 m above ground level.
H2O_CONC_2M	The water vapor concentration measured at 2 m above ground level.
H2O_CONC_50CM	The water vapor concentration measured at 50 cm above the ground.
AIR_TEMP_ABV_CNPY	The air temperature measured above the canopy.
AIR_TEMP_ABV_CNPY_2	A second air temperature measured above the canopy.
SOLENT_AIR_TEMP_ABV_CNPY	The air temperature measured by the Solent sonic anemometer using the speed of sound relationship.
SOIL_TEMP_2CM	Soil temperature at 2 cm depth.
SOIL_TEMP_5CM	Soil temperature measured at a depth of 5 cm.
SOIL_TEMP_10CM	Soil temperature at a depth of 10 cm.
SOIL_TEMP_20CM	Soil temperature at 20 cm depth.
SOIL_TEMP_50CM	Soil temperature measured at 50 cm depth.
SOIL_TEMP_100CM	The soil temperature recorded at 1 m in depth.
SOIL_TEMP_INT_3CM_3	The temperature of the 0-3 cm surface layer during the last 1 minute of the half hour from integrating thermometer 3.
SOIL_TEMP_INT_3CM_4	The temperature of the 0-3 cm surface layer during the last 1 minute of the half hour from integrating thermometer 4.
SOIL_WATER_POTENT_3CM	The soil water potential at 3 cm depth.
SOIL_WATER_POTENT_6CM	The soil water potential at 6 cm depth.
SOIL_WATER_POTENT_46CM	The soil water potential at 46 cm depth.
SOIL_WATER_CONTENT_0_15CM	The soil water content between 0 and 15 cm depth, measured by Time Domain Reflectometry (TDR).
SOIL_WATER_CONTENT_15_30CM	The soil water content between 15 and 30 cm depth, measured by Time Domain Reflectometry (TDR).
SOIL_WATER_CONTENT_30_60CM	The soil water content between 30 and 60 cm depth, measured by Time Domain Reflectometry (TDR).
SOIL_WATER_CONTENT_60_90CM	The soil water content between 60 and 90 cm depth, measured by Time Domain Reflectometry (TDR).
SOIL_WATER_CONTENT_90_120CM	The soil water content between 90 and 120 cm depth, measured by Time Domain Reflectometry (TDR).
REL_HUM_ABV_CNPY	The relative humidity measured above the canopy.
REL_HUM_ABV_CNPY_2	A second relative humidity measured above the canopy.
BOLE_TEMP_2MM	Tree bole temperature at 0.2 cm depth from north side.
BOLE_TEMP_4CM	Tree bole temperature at 4 cm depth from north

BOLE_TEMP_8CM	side. Tree bole temperature at 8 cm depth from north side.
BOLE_TEMP_12CM	Tree bole temperature at 12 cm depth from north side.
BOLE_TEMP_158MM	Tree bole temperature at 15.8 cm depth from north side.
RAINFALL	The amount of rainfall measured above the canopy over the 30 minute period.
DOWN_SHORTWAVE_RAD_ABV_CNPY	The downward (incoming) solar radiation measured above the canopy.
DOWN_SHORTWAVE_RAD_ABV_CNPY_2	A second downward (incoming) shortwave radiation measurement taken above the canopy.
UP_SHORTWAVE_RAD_ABV_CNPY	The reflected (outgoing) solar radiation measured above the canopy.
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.
SURF_PRESS	The atmospheric pressure measured at the station.
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]
LATENT_HEAT_FLUX_ABV_CNPY	[Watts] [meter ⁻²]
NET_RAD_ABV_CNPY	[Watts] [meter ⁻²]
SOIL_HEAT_FLUX_3CM_1	[Watts] [meter ⁻²]
SOIL_HEAT_FLUX_3CM_4	[Watts] [meter ⁻²]
SOIL_HEAT_FLUX_3CM_6	[Watts] [meter ⁻²]
SOIL_HEAT_FLUX_3CM_7	[Watts] [meter ⁻²]
SOIL_HEAT_FLUX_3CM_8	[Watts] [meter ⁻²]
SOIL_HEAT_FLUX_3CM_9	[Watts] [meter ⁻²]
SOIL_HEAT_FLUX_8CM	[Watts] [meter ⁻²]
CO2_FLUX_ABV_CNPY	[micromoles] [meter ⁻²] [second ⁻¹]
CO2_CONC_ABV_CNPY	[parts per million]
CO2_CONC_39M	[parts per million]
CO2_CONC_28M	[parts per million]
CO2_CONC_22M	[parts per million]
CO2_CONC_18M	[parts per million]
CO2_CONC_10M	[parts per million]
CO2_CONC_4M	[parts per million]

CO2_CONC_2M	[parts per million]
CO2_CONC_50CM	[parts per million]
BOWEN_RATIO_ABV_CNPY	[unitless]
KINEM_MOMENT_FLUX_ABV_CNPY	[meters ²][second ⁻²]
DOWN_PPFD_ABV_CNPY	[micromoles][meter ⁻²][second ⁻¹]
UP_PPFD_ABV_CNPY	[micromoles][meter ⁻²][second ⁻¹]
WIND_DIR_ABV_CNPY	[degrees]
WIND_SPEED_ABV_CNPY	[meters][second ⁻¹]
FRICTION_VEL_ABV_CNPY	[meters][second ⁻¹]
MEAN_U_WIND_SPEED	[meters][second ⁻¹]
VAR_W_WIND_SPEED	[meters ²][second ⁻²]
H2O_CONC_ABV_CNPY	[parts per thousand]
H2O_CONC_39M	[parts per thousand]
H2O_CONC_28M	[parts per thousand]
H2O_CONC_22M	[parts per thousand]
H2O_CONC_18M	[parts per thousand]
H2O_CONC_10M	[parts per thousand]
H2O_CONC_4M	[parts per thousand]
H2O_CONC_2M	[parts per thousand]
H2O_CONC_50CM	[parts per thousand]
AIR_TEMP_ABV_CNPY	[degrees Celsius]
AIR_TEMP_ABV_CNPY_2	[degrees Celsius]
SOLENT_AIR_TEMP_ABV_CNPY	[degrees Celsius]
SOIL_TEMP_2CM	[degrees Celsius]
SOIL_TEMP_5CM	[degrees Celsius]
SOIL_TEMP_10CM	[degrees Celsius]
SOIL_TEMP_20CM	[degrees Celsius]
SOIL_TEMP_50CM	[degrees Celsius]
SOIL_TEMP_100CM	[degrees Celsius]
SOIL_TEMP_INT_3CM_3	[degrees Celsius]
SOIL_TEMP_INT_3CM_4	[degrees Celsius]
SOIL_WATER_POTENT_3CM	[MegaPascals]
SOIL_WATER_POTENT_6CM	[MegaPascals]
SOIL_WATER_POTENT_46CM	[MegaPascals]
SOIL_WATER_CONTENT_0_15CM	[meter ³][meter ⁻³]
SOIL_WATER_CONTENT_15_30CM	[meter ³][meter ⁻³]
SOIL_WATER_CONTENT_30_60CM	[meter ³][meter ⁻³]
SOIL_WATER_CONTENT_60_90CM	[meter ³][meter ⁻³]
SOIL_WATER_CONTENT_90_120CM	[meter ³][meter ⁻³]
REL_HUM_ABV_CNPY	[percent]
REL_HUM_ABV_CNPY_2	[percent]
BOLE_TEMP_2MM	[degrees Celsius]
BOLE_TEMP_4CM	[degrees Celsius]
BOLE_TEMP_8CM	[degrees Celsius]
BOLE_TEMP_12CM	[degrees Celsius]
BOLE_TEMP_158MM	[degrees Celsius]
RAINFALL	[millimeters]
DOWN_SHORTWAVE_RAD_ABV_CNPY	[Watts][meter ⁻²]
DOWN_SHORTWAVE_RAD_ABV_CNPY_2	[Watts][meter ⁻²]
UP_SHORTWAVE_RAD_ABV_CNPY	[Watts][meter ⁻²]
DOWN_LONGWAVE_RAD_ABV_CNPY	[Watts][meter ⁻²]
UP_LONGWAVE_RAD_ABV_CNPY	[Watts][meter ⁻²]
SURF_PRESS	[kiloPascals]
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	[Solent sonic anemometer]
LATENT_HEAT_FLUX_ABV_CNPY	[IRGA]
NET_RAD_ABV_CNPY	[Net radiometer]
SOIL_HEAT_FLUX_3CM_1	[soil heat flux plate]
SOIL_HEAT_FLUX_3CM_4	[soil heat flux plate]
SOIL_HEAT_FLUX_3CM_6	[soil heat flux plate]
SOIL_HEAT_FLUX_3CM_7	[soil heat flux plate]
SOIL_HEAT_FLUX_3CM_8	[soil heat flux plate]
SOIL_HEAT_FLUX_3CM_9	[soil heat flux plate]
SOIL_HEAT_FLUX_8CM	[soil heat flux plate]
CO2_FLUX_ABV_CNPY	[IRGA]
CO2_CONC_ABV_CNPY	[IRGA]
CO2_CONC_39M	[IRGA]
CO2_CONC_28M	[IRGA]
CO2_CONC_22M	[IRGA]
CO2_CONC_18M	[IRGA]
CO2_CONC_10M	[IRGA]
CO2_CONC_4M	[IRGA]
CO2_CONC_2M	[IRGA]
CO2_CONC_50CM	[IRGA]
BOWEN_RATIO_ABV_CNPY	[Supplied by Investigator.]
KINEM_MOMENT_FLUX_ABV_CNPY	[Solent sonic anemometer]
DOWN_PPFD_ABV_CNPY	[quantum sensor]
UP_PPFD_ABV_CNPY	[quantum sensor]
WIND_DIR_ABV_CNPY	[vane propeller anemometer]
WIND_SPEED_ABV_CNPY	[vane propeller anemometer]
FRICTION_VEL_ABV_CNPY	[Solent sonic anemometer]
MEAN_U_WIND_SPEED	[Solent sonic anemometer]
VAR_W_WIND_SPEED	[Solent sonic anemometer]
H2O_CONC_ABV_CNPY	[krypton hygrometer]
H2O_CONC_39M	[IRGA]
H2O_CONC_28M	[IRGA]
H2O_CONC_22M	[IRGA]
H2O_CONC_18M	[IRGA]
H2O_CONC_10M	[IRGA]
H2O_CONC_4M	[IRGA]
H2O_CONC_2M	[IRGA]
H2O_CONC_50CM	[IRGA]
AIR_TEMP_ABV_CNPY	[thermometer]
AIR_TEMP_ABV_CNPY_2	[thermometer]
SOLENT_AIR_TEMP_ABV_CNPY	[Solent sonic anemometer]
SOIL_TEMP_2CM	[thermocouple]
SOIL_TEMP_5CM	[thermocouple]
SOIL_TEMP_10CM	[thermocouple]
SOIL_TEMP_20CM	[thermocouple]

SOIL_TEMP_50CM	[thermocouple]
SOIL_TEMP_100CM	[thermocouple]
SOIL_TEMP_INT_3CM_3	[integrating thermometer]
SOIL_TEMP_INT_3CM_4	[integrating thermometer]
SOIL_WATER_POTENT_3CM	[gypsum soil moisture block]
SOIL_WATER_POTENT_6CM	[gypsum soil moisture block]
SOIL_WATER_POTENT_46CM	[gypsum soil moisture block]
SOIL_WATER_CONTENT_0_15CM	[TDR]
SOIL_WATER_CONTENT_15_30CM	[TDR]
SOIL_WATER_CONTENT_30_60CM	[TDR]
SOIL_WATER_CONTENT_60_90CM	[TDR]
SOIL_WATER_CONTENT_90_120CM	[TDR]
REL_HUM_ABV_CNPY	[dewpoint hygrometer]
REL_HUM_ABV_CNPY_2	[dewpoint hygrometer]
BOLE_TEMP_2MM	[thermocouple]
BOLE_TEMP_4CM	[thermocouple]
BOLE_TEMP_8CM	[thermocouple]
BOLE_TEMP_12CM	[thermocouple]
BOLE_TEMP_158MM	[thermocouple]
RAINFALL	[tipping bucket rain gauge]
DOWN_SHORTWAVE_RAD_ABV_CNPY	[pyranometer]
DOWN_SHORTWAVE_RAD_ABV_CNPY_2	[pyranometer]
UP_SHORTWAVE_RAD_ABV_CNPY	[pyranometer]
DOWN_LONGWAVE_RAD_ABV_CNPY	[pyrgeometer]
UP_LONGWAVE_RAD_ABV_CNPY	[pyrgeometer]
SURF_PRESS	[barometer]
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	SSA-90A-FLXTR	SSA-90A-FLXTR	None	None	None	None
SUB_SITE	9TF01-FLX01	9TF01-FLX01	None	None	None	None
DATE_OBS	01-APR-96	30-DEC-96	None	None	None	None
TIME_OBS	0	2330	None	None	None	None
SENSIBLE_HEAT_FLUX_ABV_CNPY	-161.03	696.11	-999	None	None	None
LATENT_HEAT_FLUX_ABV_CNPY	-17.75	545.3	-999	None	None	None
NET_RAD_ABV_CNPY	-85.387	833.85	-999	None	None	None
SOIL_HEAT_FLUX_3CM_1	-9.29	52.31	-999	None	None	None
SOIL_HEAT_FLUX_3CM_4	-20.37	52.01	-999	None	None	None
SOIL_HEAT_FLUX_3CM_6	-23.83	64.07	-999	None	None	None
SOIL_HEAT_FLUX_3CM_7	-18.32	52.69	-999	None	None	None
SOIL_HEAT_FLUX_3CM_8	-18.24	48.1	-999	None	None	None
SOIL_HEAT_FLUX_3CM_9	-31.5	29.26	-999	None	None	None
SOIL_HEAT_FLUX_8CM	-10.45	47.37	-999	None	None	None
CO2_FLUX_ABV_CNPY	-35.289	26.052	-999	None	None	None
CO2_CONC_ABV_CNPY	323.91	402.07	-999	None	None	None

CO2_CONC_39M	-34.642	32.327	-999	None	None	None
CO2_CONC_28M	25.895	103.71	-999	None	None	None
CO2_CONC_22M	-38.455	32.148	-999	None	None	None
CO2_CONC_18M	32.646	104.55	-999	None	None	None
CO2_CONC_10M	324.8	403.34	-999	None	None	None
CO2_CONC_4M	324.63	419.14	-999	None	None	None
CO2_CONC_2M	321.16	416.14	-999	None	None	None
CO2_CONC_50CM	320.09	413.04	-999	None	None	None
BOWEN_RATIO_ABV_CNPY	-4	4	-999	None	None	None
KINEM_MOMENT_FLUX_ABV_CNPY	-2.65	.144	-999	None	None	None
DOWN_PPFD_ABV_CNPY	-.83782	2021.7	-999	None	None	None
UP_PPFD_ABV_CNPY	-.94906	194.43	-999	None	None	None
WIND_DIR_ABV_CNPY	12.746	349.48	-999	None	None	None
WIND_SPEED_ABV_CNPY	0	8.994	-999	None	None	None
FRICTION_VEL_ABV_CNPY	.002	1.628	-999	None	None	None
MEAN_U_WIND_SPEED	.022	9.673	-999	None	None	None
VAR_W_WIND_SPEED	0	3.681	-999	None	None	None
H2O_CONC_ABV_CNPY	-.215	22.144	-999	None	None	None
H2O_CONC_39M	320.55	516.64	-999	None	None	None
H2O_CONC_28M	324.84	656.1	-999	None	None	None
H2O_CONC_22M	326.1	681.11	-999	None	None	None
H2O_CONC_18M	307.29	819.24	-999	None	None	None
H2O_CONC_10M	2.871	27.459	-999	None	None	Blank
H2O_CONC_4M	2.891	25.854	-999	None	None	Blank
H2O_CONC_2M	2.896	26.526	-999	None	None	Blank
H2O_CONC_50CM	2.909	26.307	-999	None	None	Blank
AIR_TEMP_ABV_CNPY	-34.451	31.492	-999	None	None	None
AIR_TEMP_ABV_CNPY_2	-33.378	30.343	-999	None	None	None
SOLENT_AIR_TEMP_ABV_CNPY	-34.207	32.67	-999	None	None	None
SOIL_TEMP_2CM	-2.9	17.64	-999	None	None	None
SOIL_TEMP_5CM	-2.341	15.495	-999	None	None	None
SOIL_TEMP_10CM	-2.117	14.838	-999	None	None	None
SOIL_TEMP_20CM	-1.584	13.454	-999	None	None	None
SOIL_TEMP_50CM	-.602	11.791	-999	None	None	None
SOIL_TEMP_100CM	.223	10.241	-999	None	None	None
SOIL_TEMP_INT_3CM_3	-6.096	20.6	-999	None	None	None
SOIL_TEMP_INT_3CM_4	-2.103	21.48	-999	None	None	None
SOIL_WATER_POTENT_3CM	-1.3	-.003	-999	None	None	None
SOIL_WATER_POTENT_6CM	-1.3	-.006	-999	None	None	None
SOIL_WATER_POTENT_46CM	-1.3	-.015	-999	None	None	None
SOIL_WATER_CONTENT_0_15CM	.14	.7	-999	None	None	None
SOIL_WATER_CONTENT_15_30CM	.08	.46	-999	None	None	None
SOIL_WATER_CONTENT_30_60CM	.17	.38	-999	None	None	None
SOIL_WATER_CONTENT_60_90CM	.2	.37	-999	None	None	None

SOIL_WATER_CONTENT_90_120CM	.24	.36	-999	None	None	None
REL_HUM_ABV_CNPY	19.139	105	-999	None	None	None
REL_HUM_ABV_CNPY_2	27.707	121.55	-999	None	None	None
BOLE_TEMP_2MM	-35.61	36.36	-999	None	None	None
BOLE_TEMP_4CM	-35.66	30.25	-999	None	None	None
BOLE_TEMP_8CM	-35.57	28.59	-999	None	None	None
BOLE_TEMP_12CM	-35.26	28	-999	None	None	None
BOLE_TEMP_158MM	-35.26	30.31	-999	None	None	None
RAINFALL	0	20.57	None	None	None	None
DOWN_SHORTWAVE_RAD_ABV_CNPY	-5.106	974.41	-999	None	None	None
DOWN_SHORTWAVE_RAD_ABV_CNPY_2	0	972.8	-999	None	None	None
UP_SHORTWAVE_RAD_ABV_CNPY	-.91769	143.75	-999	None	None	None
DOWN_LONGWAVE_RAD_ABV_CNPY	125.42	405.23	-999	None	None	None
UP_LONGWAVE_RAD_ABV_CNPY	189.8	479.07	-999	None	None	None
SURF_PRESS	91.23	96.86	-999	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	18-AUG-99	18-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 record from a sample data file on the CD-ROM.

```
SITE_NAME,SUB_SITE,DATE_OBS,TIME_OBS,SENSIBLE_HEAT_FLUX_ABV_CNPY,  
LATENT_HEAT_FLUX_ABV_CNPY,NET_RAD_ABV_CNPY,SOIL_HEAT_FLUX_3CM_1,  
SOIL_HEAT_FLUX_3CM_4,SOIL_HEAT_FLUX_3CM_6,SOIL_HEAT_FLUX_3CM_7,  
SOIL_HEAT_FLUX_3CM_8,SOIL_HEAT_FLUX_3CM_9,SOIL_HEAT_FLUX_8CM,CO2_FLUX_ABV_CNPY,  
CO2_CONC_ABV_CNPY,CO2_CONC_39M,CO2_CONC_28M,CO2_CONC_22M,CO2_CONC_18M,  
CO2_CONC_10M,CO2_CONC_4M,CO2_CONC_2M,CO2_CONC_50CM,BOWEN_RATIO_ABV_CNPY,  
KINEM_MOMENT_FLUX_ABV_CNPY,DOWN_PPFD_ABV_CNPY,UP_PPFD_ABV_CNPY,  
WIND_DIR_ABV_CNPY,WIND_SPEED_ABV_CNPY,FRICTION_VEL_ABV_CNPY,MEAN_U_WIND_SPEED,  
VAR_W_WIND_SPEED,H2O_CONC_ABV_CNPY,H2O_CONC_39M,H2O_CONC_28M,H2O_CONC_22M,  
H2O_CONC_18M,H2O_CONC_10M,H2O_CONC_4M,H2O_CONC_2M,H2O_CONC_50CM,  
AIR_TEMP_ABV_CNPY,AIR_TEMP_ABV_CNPY_2,SOLENT_AIR_TEMP_ABV_CNPY,SOIL_TEMP_2CM,  
SOIL_TEMP_5CM,SOIL_TEMP_10CM,SOIL_TEMP_20CM,SOIL_TEMP_50CM,SOIL_TEMP_100CM,  
SOIL_TEMP_INT_3CM_3,SOIL_TEMP_INT_3CM_4,SOIL_WATER_POTENT_3CM,  
SOIL_WATER_POTENT_6CM,SOIL_WATER_POTENT_46CM,SOIL_WATER_CONTENT_0_15CM,  
SOIL_WATER_CONTENT_15_30CM,SOIL_WATER_CONTENT_30_60CM,SOIL_WATER_CONTENT_60_90CM,  
SOIL_WATER_CONTENT_90_120CM,REL_HUM_ABV_CNPY,REL_HUM_ABV_CNPY_2,BOLE_TEMP_2MM,  
BOLE_TEMP_4CM,BOLE_TEMP_8CM,BOLE_TEMP_12CM,BOLE_TEMP_158MM,RAINFALL,  
DOWN_SHORTWAVE_RAD_ABV_CNPY,DOWN_SHORTWAVE_RAD_ABV_CNPY_2,  
UP_SHORTWAVE_RAD_ABV_CNPY,DOWN_LONGWAVE_RAD_ABV_CNPY,UP_LONGWAVE_RAD_ABV_CNPY,  
SURF_PRESS,CRTFCN_CODE,REVISION_DATE  
'SSA-90A-FLXTR','9TF01-FLX01',01-JUN-96,0,71.004,22.942,209.19,21.89,18.25,  
25.16,15.71,14.27,14.59,21.03,-.3088,360.12,-999.0,-999.0,-999.0,-999.0,  
-999.0,-999.0,-999.0,-999.0,2.755,-.035,665.92,22.477,152.14,.905,.188,.716,  
.15,6.85,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,20.871,  
19.806,20.203,12.12,10.591,10.011,8.502,5.983,4.139,13.21,15.69,-.031,-.031,  
-.032,.58,.44,.37,.36,.34,26.505,34.811,-999.0,-999.0,-999.0,-999.0,-999.0,  
0.0,-999.0,319.87,-999.0,-999.0,-999.0,93.91,'CPI',18-AUG-99  
'SSA-90A-FLXTR','9TF01-FLX01',01-JUN-96,30,55.252,55.375,121.15,20.78,17.01,  
23.49,15.4,13.57,13.87,19.59,1.3347,360.11,-999.0,-999.0,-999.0,-999.0,  
-999.0,-999.0,-999.0,-999.0,.888,-.238,505.26,16.884,64.246,2.261,.488,2.556,  
.293,7.983,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,20.447,  
19.835,20.047,11.98,10.55,10.0,8.54,5.99,4.143,13.09,15.32,-.031,-.031,-.032,  
.58,.44,.37,.36,.34,30.952,38.186,-999.0,-999.0,-999.0,-999.0,-999.0,0.0,  
-999.0,242.5,-999.0,-999.0,-999.0,93.91,'CPI',18-AUG-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

There are many equations and formulae used in the calculations of fluxes from the raw voltage signals. Readers are referred to the relevant references for details.

9.2 Data Processing Sequence

9.2.1 Processing Steps

Averages, variances, and covariances are calculated in real time, and coordinate rotation is applied on the half-hourly covariances and variances. WPL corrections were made to the water vapor and carbon dioxide fluxes measured using the closed-path LI-COR 6262 IRGA.

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

WPL corrections were made to the water vapor and carbon dioxide fluxes measured using the closed-path LI-COR 6262 IRGA. Broadening correction was done, but not online (see Chen et al., 1998, for summary of theory).

9.3.2 Calculated Variables

The Bowen ratio is the ratio of the sensible to latent heat flux.

9.4 Graphs and Plots

See Black et al., 1996; Chen et al., 1998; Blanken, 1997; and Yang, 1998.

10. Errors

10.1 Sources of Error

None given.

10.2 Quality Assessment

10.2.1 Data Validation by Source

Data were checked and flagged for various conditions in the original data base at UBC (Z. Nesic). Relatively little data were missing in 4-m measurements in 1994 and 39-m measurements in 1996.

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.

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

The soil heat flux plates at plots 2, 3, and 5 did not collect any usable data.

11.3 Usage Guidance

Read this document carefully or contact Drs. T.A. Black and Z. Chen.

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 aspen forest.

13. Future Modifications and Plans

Data collection from the SSA-OA tower continued after 1996. Contact Dr. T.A. Black for information about these data.

14. Software

14.1 Software Description

None given.

14.2 Software Access

None given.

15. Data Access

The SSA-OA 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

Baldocchi, D.D. 1997. Flux footprints within and over forest canopy. *Boundary-Layer Meteorology*, 85, 273-292.

Black, T.A., G. den Hartog, H.H. Neumann, P.D. Blanken, P.C. Yang, C. Russell, and Z. Nesic. 1996. Annual cycle of water vapor and carbon dioxide fluxes in and above a boreal aspen forest. *Global Change Biology*, 2, 101-111.

Blanken, P.D. 1997. Evaporation within and above a boreal aspen forest. Ph.D. Thesis of UBC , 79-84.

Chen, W.J., T.A. Black, P.C. Yang, A.G. Barr, H.H. Neumann, Z. Nesic, P.D. Blanken, M.D. Novak, J. Eley, R.J. Ketler, and R. Cuenca. 1998. Effects of climatic variability on the annual carbon sequestration by a boreal aspen forest. *Global Change Biology* (in press).

Fritschen, L.J. and L.W. Gay. 1979. *Environmental Instrumentation*. Springer-Verlag, Berlin, New York and Heidelberg.

Fuchs, M. and C.B. Tanner. 1968. Calibration and field tests of soil heat flux plates. *Soil Science Society of America Proceedings*, 32, 326-328.

Hook, W.R. and N.J. Livingston. 1996. Errors in converting time domain reflectometry measurements of propagation velocity to estimated of soil water content. *Soil Sci. Soc. Amer. J.*, 59, 35-41.

Kaimal, J.C. and J.E. Gaynor. 1991. Another look at sonic thermometry. *Boundary-Layer Meteorology*, 56, 401-410.

Lee, X., T.A. Black, and M.D. Novak. 1994. Comparison of flux measurements with open-and closed-path gas analyzers above an agricultural field and a forest floor. *Boundary-Layer Meteorology*, 67, 1995-202.

Leuning, R. and K.M. King. 1992. Comparison of eddy covariance measurements of CO₂ fluxes by open- and closed-path CO₂ analyzers. *Boundary-Layer Meteorology*, 59, 297-311.

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.

Pearcy, R.W., J. Ehleringer, H.A. Mooney, and P.W. Rundel. 1991. *Plant physiological ecology: Field methods and instrumentation*. Chapman and Hall, London and New York.

Schuepp P.H., M.Y. Leclerc, J.I. MacPerson, and R.L. Desjardins. 1990. Footprint prediction of scalar fluxes from analytical solutions of the diffusion equation. *Boundary-Layer Meteorology*, 50, 355-373.

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.

Webb, E.K., G.I. Pearman, and R. Leuning. 1980. Correction of flux measurements for density effects due to heat and water vapor transfer. Quarterly Journal of the Royal Meteorological Society, 106, 85-100.

Yang, P.C. 1998. Carbon dioxide flux within and above a boreal aspen forest. Ph.D. thesis, University of British Columbia, Vancouver, Canada.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List Of Acronyms

AES	- Atmospheric Environment Service
AFM	- Airborne Fluxes and Meteorology
ASCII	- American Standard Code for Information Interchange
ATD	- Atmospheric Technology Division
ATI	- Applied Technologies, Inc.
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	- Hyper-Text Markup Language
i.d.	- inner diameter

IFC	- Intensive Field Campaign
IR	- Infrared
IRGA	- Infrared Gas Analyzer
LAI	- Leaf Area Index
NAD83	- North American Datum of 1983
NASA	- National Aeronautics and Space Administration
NEP	- Net Ecosystem Productivity
NSA	- Northern Study Area
OA	- Old Aspen
ORNL	- Oak Ridge National Laboratory
PANP	- Prince Albert National Park
PAR	- Photosynthetically Active Radiation
PC	- Personal Computer
PPFD	- Photosynthetic Photon Flux Density
SRC	- Saskatchewan Research Council
SSA	- Southern Study Area
TDR	- Time Domain Reflectometry
TF	- Tower Flux
UBC	- University of British Columbia
URL	- Uniform Resource Locator

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