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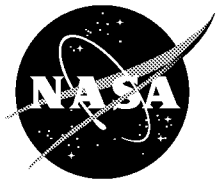

Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and Karl Huemmrich, Editors

Volume 190

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

T. Andrew Black, Z. Chen, and Zoran Nesic
University of British Columbia, Vancouver

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

October 2000

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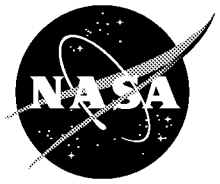

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BOREAS TF-1 SSA-OA Understory Flux, Meteorological, and Soil Temperature Data

T. Andrew Black, Z. Chen, Zoran Nesic

Summary

The BOREAS TF-1 team collected energy, carbon dioxide, and momentum flux data under the canopy along with meteorological and soils data at the BOREAS SSA-OA site from mid-October to mid-November of 1993 and throughout all of 1994. The data are available in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

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

1.2 Data Set Introduction

The Tower Flux (TF)-01 team collected understory measurements of heat, carbon dioxide, and momentum fluxes along with meteorological, soil temperature, soil moisture, snow temperature, and tree bole temperature data at the BOReal Ecosystem-Atmosphere Study (BOREAS) Southern Study Area (SSA) Old Aspen (OA) tower site. These measurements were made in conjunction with above-canopy and profile measurements made at this site by the TF-02 group. The understory data were collected from mid-October to mid-November of 1993 and throughout all of 1994.

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, H_2O and CO_2 above the aspen stand throughout the year.
- To obtain from the CO_2 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 H_2O and CO_2 within the stand.
- To take part in the evaluation of methods of estimating nocturnal CO_2 in and above the stand.

1.4 Summary of Parameters

The following variables were measured from a 4-m tower under the aspen canopy: latent heat flux, sensible heat flux, CO_2 flux, CO_2 concentration, momentum flux, Bowen ratio, air temperature, wind speed and direction, friction velocity, water vapor concentration, and relative humidity. Other measurements collected to describe the soil and forest: soil heat flux, soil temperature, soil water potential, soil water content, tree bole temperatures, snow temperatures, net radiation, Photosynthetic Photon Flux Density (PPFD) transmitted through the canopy, and air pressure.

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 1993 and 1994 under-canopy data collection effort.

The fluxes of momentum, sensible heat, latent heat (water vapor), and carbon dioxide using the eddy correlation method were measured at the 6-m height in 1993 and the 4 m height in 1994. These measurements were made on a 6 m tall scaffold tower located above 40 m south of the main flux tower at the OA site. 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 (CO_2/H_2O) analyzer (IRGA) (model 6262, LI-COR, Inc., Lincoln, NE) and a krypton open-path hygrometer (model KH20, Campbell Scientific, Inc., Logan, UT). Air was drawn at 8.0 L/min down 3 m of 3.2 mm inner diameter (i.d.) sampling tubing (model Bev-a-line, Thermoplastic Processes, Inc., Sterling, NJ), then down 1.7 m of 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 delay time was 0.8 s. The IRGA was operated in absolute mode with dry air at zero CO_2 concentration flowing through the reference cell at 25 cm^3/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 home-made, 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); snow temperature (30-gauge chromel-constantan thermocouples); tree bole temperatures at 0.2, 4.0, 8.0, 12.0, and 15.8 cm (thermocouple wire); net radiation and PPFD (Swissteco net radiometer and LI-COR quantum sensor carried on a tram that traveled back and forth along a 65 m transect on two steel wires suspended 3-4 m above the ground) above the understory; air humidity below (model HMP-35C sensor, Vaisala, Inc.,

Woburn, MA) the overstory; wind speed and direction below the overstory (model 05031 vane propeller anemometer, R.M. Young Co., Traverse City, MI); and precipitation measured using a weighing rain gauge (Belfort Instrument Co., Baltimore, MD).

1.6 Related Data Sets

BOREAS TF-01 SSA-OA Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-01 SSA-OA Soil Characteristics Data
BOREAS TF-02 SSA-OA Tower Flux and Meteorological 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

Contact 1:
Mr. Zoran Nesic
University of British Columbia
Department of Soil Science
2357 Main Mall Rm. 139
Vancouver, BC V6T 1Z4 CANADA
(604) 822-3479, 822-5654 (Lab)
(604) 822-8639 (fax)
NESIC@PPC.UBC.CA

Contact 2:
Prof. T. Andy Black
University of British Columbia
Department of Soil Science
2357 Main Mall Rm. 139
Vancouver, BC V6T 1Z4 CANADA
(604) 822-2730
(604) 822-8639 (fax)
ablack@unixg.ubc.ca

Contact 3:
K. Fred Huemmrich
University of Maryland
NASA GSFC
Code 923
Greenbelt, MD 20771
(301) 286-4862
(301) 286-0239 (fax)
Karl.Huemmrich@gsfc.nasa.gov

3. Theory of Measurements

Measurements of the fluxes of momentum, sensible heat, water vapor, and CO_2 were made with the eddy covariance technique. Velocity components, air temperature, water vapor density, and CO_2 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 CO_2 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 CO_2 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 -10 °C to over 25 °C were experienced.

4.1.2 Source/Platform

A 37-m walkup 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 CO_2, energy, water vapor, and momentum between the forest and atmosphere at the SSA-OA.

4.1.4 Key Variables

Variables measured using eddy covariance: CO_2 and water vapor fluxes, momentum fluxes, sensible heat fluxes, and latent heat fluxes.

Supporting meteorological variables: net radiation and PPFD under the canopy, wind speed, wind direction, air temperature, relative and absolute humidity, air temperature, soil temperature, soil heat flux, soil moisture, soil water potential, snow temperature, tree bole temperature, 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 CO_2/H_2O 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 CO_2 or H_2O 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

Beneath aspen canopy flux measurement sensors were supported by a 2.1-m-long horizontal boom at a bearing of 238° fastened to the side of 6-m-tall scaffold-type understory tower located approximately 40 m from the main tower.

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), and tree bole temperatures at 0.2, 4.0, 8.0, 12.0, and 15.8 cm into the bole (thermocouple wire).

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 Shefield 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 1994, zeroing and calibration of the LI-6262 IRGA was done manually, using 350 ppm CO_2 cylinders (Medigas) calibrated using TF02 (AES) cylinders and a LI-COR dewpoint generator.

4.2.1.1 Tolerance

CO_2 concentration was accurate to within ± 1 mmol/mol.

4.2.2 Frequency of Calibration

Not given.

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 H_2O krypton gas analyzer for measuring water vapor density in the air, and a closed-path dual H_2O/CO_2 IRGA (LI-COR 6262) for measuring water vapor density and CO_2 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.

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.

The understory measurements were collected from a 6-m scaffold tower about 40 m from the main tower.

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

Under-canopy data were collected from 12-October to 13-November-1993 and from 01-January to 31-December-1994.

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_BELOW_CNPY
LIC_LATENT_HEAT_FLUX_4M
KRYPTON_LATENT_HEAT_FLUX_4M
NET_RAD_10CM
SOIL_HEAT_FLUX_3CM_1
SOIL_HEAT_FLUX_3CM_2
SOIL_HEAT_FLUX_3CM_3
SOIL_HEAT_FLUX_3CM_4
SOIL_HEAT_FLUX_3CM_5
SOIL_HEAT_FLUX_3CM_6
SOIL_HEAT_FLUX_3CM_7
SOIL_HEAT_FLUX_3CM_8
SOIL_HEAT_FLUX_3CM_9
MEAN_SOIL_HEAT_FLUX_3CM
SOIL_HEAT_FLUX_8CM
SOIL_HEAT_STORAGE_RATE
SURFACE_SOIL_HEAT_FLUX
CO2_FLUX_BELOW_CNPY
MEAN_CO2_CONC_4M
SDEV_CO2_CONC_4M
BOWEN_RATIO_4M
KINEM_MOMENT_FLUX_4M
DOWN_PPFD_10CM
WIND_DIR_4M
WIND_SPEED_4M
FRICTION_VEL_4M
WIND_SPEED_RESULTANT_VECTOR_4M
WIND_DIR_RESULTANT_4M
MEAN_U_WIND_SPEED_4M
MEAN_W_WIND_SPEED_4M
VAR_W_WIND_SPEED_4M
SDEV_W_WIND_SPEED_4M
ABS_HUM_4M
MEAN_LIC_ABS_HUM_4M
SDEV_LIC_ABS_HUM_4M
MEAN_KRYPTON_ABS_HUM_4M
SDEV_KRYPTON_ABS_HUM_4M
MEAN_AIR_TEMP_4M
SDEV_AIR_TEMP_4M
SOLENT_AIR_TEMP_4M
SOIL_TEMP_2CM
SOIL_TEMP_5CM
SOIL_TEMP_10CM
```

SOIL_TEMP_20CM
SOIL_TEMP_50CM
SOIL_TEMP_100CM
MEAN_SOIL_TEMP_INT_3CM
SOIL_WATER_POTENT_3CM
SOIL_WATER_POTENT_6CM
SOIL_WATER_POTENT_46CM
GRAV_SOIL_WATER_CONTENT_3CM
REL_HUM_4M
BOLE_TEMP_2MM
BOLE_TEMP_4CM
BOLE_TEMP_8CM
BOLE_TEMP_12CM
BOLE_TEMP_158MM
HAZEL_BOLE_TEMP_2MM
SNOW_IRT_TEMP
SNOW_TEMP_6CM
SNOW_TEMP_12CM
SNOW_TEMP_18CM
SNOW_TEMP_24CM
SNOW_TEMP_30CM
SNOW_TEMP_36CM
SURF_PRESS
DATA_QUALITY_FLAG
COMMENTS
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_BELOW_CNPY	The sensible heat flux measured below the canopy.
LIC_LATENT_HEAT_FLUX_4M	The latent heat flux measured with the LI-COR instrument at 4 m height.
KRYPTON_LATENT_HEAT_FLUX_4M	The latent heat flux measured with the Krypton instrument at 4 m height.

NET_RAD_10CM	The net radiation measured at 10 cm above the ground.
SOIL_HEAT_FLUX_3CM_1	The soil heat flux measured at 3 cm depth at plot 1.
SOIL_HEAT_FLUX_3CM_2	The soil heat flux measured at 3 cm depth at plot 2.
SOIL_HEAT_FLUX_3CM_3	The soil heat flux measured at 3 cm depth at plot 3.
SOIL_HEAT_FLUX_3CM_4	The soil heat flux measured at 3 cm depth at plot 4.
SOIL_HEAT_FLUX_3CM_5	The soil heat flux measured at 3 cm depth at plot 5.
SOIL_HEAT_FLUX_3CM_6	The soil heat flux measured at 3 cm depth at plot 6.
SOIL_HEAT_FLUX_3CM_7	The soil heat flux measured at 3 cm depth at plot 7.
SOIL_HEAT_FLUX_3CM_8	The soil heat flux measured at 3 cm depth at plot 8.
SOIL_HEAT_FLUX_3CM_9	The soil heat flux measured at 3 cm depth at plot 9.
MEAN_SOIL_HEAT_FLUX_3CM	The mean soil heat flux at 3 cm, the average of the 9 soil heat flux plates.
SOIL_HEAT_FLUX_8CM	The soil heat flux measured at 8 cm depth.
SOIL_HEAT_STORAGE_RATE	Rate of change of the heat storage in the 0-3 cm soil layer calculated using the MEAN_SOIL_HEAT_FLUX_3CM and GRAV_SOIL WATER_CONTENT_3CM.
SURFACE_SOIL_HEAT_FLUX	Soil surface heat flux, the sum of MEAN_SOIL_HEAT_FLUX_3CM and SOIL_HEAT_STORAGE_RATE.
CO2_FLUX_BELOW_CNPY	The carbon dioxide flux measured below the canopy.
MEAN_CO2_CONC_4M	The mean carbon dioxide concentration measured at 4 m above the ground.
SDEV_CO2_CONC_4M	The standard deviation of the carbon dioxide concentration measured at 4 m above the ground.
BOWEN_RATIO_4M	The Bowen Ratio at 4 m above ground level.
KINEM_MOMENT_FLUX_4M	Kinematic momentum flux density measured at 4 m above the ground.
DOWN_PPFD_10CM	The incoming photosynthetic photon flux density measured at 10 cm above the ground.
WIND_DIR_4M	The wind direction measured at 4 m above ground level.
WIND_SPEED_4M	Mean horizontal wind speed measured at 4 m.
FRICTION_VEL_4M	The friction velocity measured at 4 m height above the ground.
WIND_SPEED_RESULTANT_VECTOR_4M	Resultant mean horizontal wind speed at 4 m above the ground.
WIND_DIR_RESULTANT_4M	The resultant mean horizontal wind direction at 4 m above the ground.
MEAN_U_WIND_SPEED_4M	Mean streamwise wind speed at 4 m above ground level.
MEAN_W_WIND_SPEED_4M	Mean vertical wind speed at 4 m above ground level.
VAR_W_WIND_SPEED_4M	Variance of the vertical wind velocity measured at 4 m above ground level.

SDEV_W_WIND_SPEED_4M	Standard deviation of the vertical wind velocity measured at 4 m above ground level.
ABS_HUM_4M	The absolute humidity measured at 4 m above the ground.
MEAN_LIC_ABS_HUM_4M	Absolute humidity measured using a LI-COR instrument at 4 m above ground level.
SDEV_LIC_ABS_HUM_4M	Standard deviation of absolute humidity measured using a LI-COR instrument at 4 m above ground level.
MEAN_KRYPTON_ABS_HUM_4M	Absolute humidity measured using a Krypton instrument at 4 m above ground level.
SDEV_KRYPTON_ABS_HUM_4M	Standard deviation of absolute humidity measured using a Krypton instrument at 4 m above ground level.
MEAN_AIR_TEMP_4M	The mean air temperature measured at 4 m above the ground.
SDEV_AIR_TEMP_4M	The standard deviation of the air temperature measured at 4 m above the ground.
SOLENT_AIR_TEMP_4M	The air temperature at 4 m above ground level, 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.
MEAN_SOIL_TEMP_INT_3CM	The temperature of the 0-3 cm surface layer during the last 1 minute of the half hour. The average of two integrating thermometers.
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.
GRAV_SOIL_WATER_CONTENT_3CM	Gravimetric soil water content of the 0-3 cm soil layer.
REL_HUM_4M	The relative humidity measured at 4 m above the ground level.
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 side.
BOLE_TEMP_8CM	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.
HAZEL_BOLE_TEMP_2MM	The temperature at a depth of 0.2 cm inside the stem of a hazelnut plant.
SNOW_IRT_TEMP	Snow surface temperature measured with an infrared thermometer.
SNOW_TEMP_6CM	Snow temperature 6 cm above ground level.
SNOW_TEMP_12CM	Snow temperature 12 cm above ground level.
SNOW_TEMP_18CM	Snow temperature 18 cm above ground level.

SNOW_TEMP_24CM	Snow temperature 24 cm above ground level.
SNOW_TEMP_30CM	Snow temperature 30 cm above ground level.
SNOW_TEMP_36CM	Snow temperature 36 cm above ground level.
SURF_PRESS	The atmospheric pressure measured at the station.
DATA_QUALITY_FLAG	Data quality flags, see documentation for description of codes.
COMMENTS	Descriptive information to clarify or enhance the understanding of the other entered data.
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_BELOW_CNPY	[Watts][meter^-2]
LIC_LATENT_HEAT_FLUX_4M	[Watts][meter^-2]
KRYPTON_LATENT_HEAT_FLUX_4M	[Watts][meter^-2]
NET_RAD_10CM	[Watts][meter^-2]
SOIL_HEAT_FLUX_3CM_1	[Watts][meter^-2]
SOIL_HEAT_FLUX_3CM_2	[Watts][meter^-2]
SOIL_HEAT_FLUX_3CM_3	[Watts][meter^-2]
SOIL_HEAT_FLUX_3CM_4	[Watts][meter^-2]
SOIL_HEAT_FLUX_3CM_5	[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]
MEAN_SOIL_HEAT_FLUX_3CM	[Watts][meter^-2]
SOIL_HEAT_FLUX_8CM	[Watts][meter^-2]
SOIL_HEAT_STORAGE_RATE	[Watts][meter^-2]
SURFACE_SOIL_HEAT_FLUX	[Watts][meter^-2]
CO2_FLUX_BELOW_CNPY	[micromoles][meters^-2][second^-1]
MEAN_CO2_CONC_4M	[parts per million]
SDEV_CO2_CONC_4M	[parts per million]
BOWEN_RATIO_4M	[unitless]
KINEM_MOMENT_FLUX_4M	[meter^2][second^-2]
DOWN_PPFD_10CM	[micromoles][meters^-2][second^-1]
WIND_DIR_4M	[degrees from North]
WIND_SPEED_4M	[meters][second^-1]
FRICTION_VEL_4M	[meters][second^-1]
WIND_SPEED_RESULTANT_VECTOR_4M	[meters][second^-1]
WIND_DIR_RESULTANT_4M	[degrees from North]
MEAN_U_WIND_SPEED_4M	[meters][second^-1]
MEAN_W_WIND_SPEED_4M	[meters][second^-1]

VAR_W_WIND_SPEED_4M	[meter^2][second^-2]
SDEV_W_WIND_SPEED_4M	[meters][second^-1]
ABS_HUM_4M	[grams][meter^-3]
MEAN_LIC_ABS_HUM_4M	[grams][meter^-3]
SDEV_LIC_ABS_HUM_4M	[grams][meter^-3]
MEAN_KRYPTON_ABS_HUM_4M	[grams][meter^-3]
SDEV_KRYPTON_ABS_HUM_4M	[grams][meter^-3]
MEAN_AIR_TEMP_4M	[degrees Celsius]
SDEV_AIR_TEMP_4M	[degrees Celsius]
SOLENT_AIR_TEMP_4M	[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]
MEAN_SOIL_TEMP_INT_3CM	[degrees Celsius]
SOIL_WATER_POTENT_3CM	[MegaPascals]
SOIL_WATER_POTENT_6CM	[MegaPascals]
SOIL_WATER_POTENT_46CM	[MegaPascals]
GRAV_SOIL_WATER_CONTENT_3CM	[meter^3][meter^-3]
REL_HUM_4M	[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]
HAZEL_BOLE_TEMP_2MM	[degrees Celsius]
SNOW_IRT_TEMP	[degrees Celsius]
SNOW_TEMP_6CM	[degrees Celsius]
SNOW_TEMP_12CM	[degrees Celsius]
SNOW_TEMP_18CM	[degrees Celsius]
SNOW_TEMP_24CM	[degrees Celsius]
SNOW_TEMP_30CM	[degrees Celsius]
SNOW_TEMP_36CM	[degrees Celsius]
SURF_PRESS	[kiloPascals]
DATA_QUALITY_FLAG	[none]
COMMENTS	[none]
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_BELOW_CNPY	[Solent sonic anemometer]
LIC_LATENT_HEAT_FLUX_4M	[IRGA]
KRYPTON_LATENT_HEAT_FLUX_4M	[krypton hygrometer]
NET_RAD_10CM	[Net radiometer]

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SOIL_HEAT_FLUX_3CM_1            [soil heat flux plate]
SOIL_HEAT_FLUX_3CM_2            [soil heat flux plate]
SOIL_HEAT_FLUX_3CM_3            [soil heat flux plate]
SOIL_HEAT_FLUX_3CM_4            [soil heat flux plate]
SOIL_HEAT_FLUX_3CM_5            [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]
MEAN_SOIL_HEAT_FLUX_3CM         [soil heat flux plate]
SOIL_HEAT_FLUX_8CM              [soil heat flux plate]
SOIL_HEAT_STORAGE_RATE          [Supplied by Investigator.]
SURFACE_SOIL_HEAT_FLUX          [Supplied by Investigator.]
CO2_FLUX_BELOW_CNPY             [IRGA]
MEAN_CO2_CONC_4M                [IRGA]
SDEV_CO2_CONC_4M                [IRGA]
BOWEN_RATIO_4M                  [Supplied by Investigator.]
KINEM_MOMENT_FLUX_4M            [Solent sonic anemometer]
DOWN_PPFD_10CM                  [quantum sensor]
WIND_DIR_4M                     [vane propeller anemometer]
WIND_SPEED_4M                   [vane propeller anemometer]
FRICTION_VEL_4M                 [Solent sonic anemometer]
WIND_SPEED_RESULTANT_VECTOR_4M [vane propeller anemometer]
WIND_DIR_RESULTANT_4M           [vane propeller anemometer]
MEAN_U_WIND_SPEED_4M            [Solent sonic anemometer]
MEAN_W_WIND_SPEED_4M            [Solent sonic anemometer]
VAR_W_WIND_SPEED_4M             [Solent sonic anemometer]
SDEV_W_WIND_SPEED_4M            [Solent sonic anemometer]
ABS_HUM_4M                      [humidity sensor]
MEAN_LIC_ABS_HUM_4M             [IRGA]
SDEV_LIC_ABS_HUM_4M             [IRGA]
MEAN_KRYPTON_ABS_HUM_4M         [krypton hygrometer]
SDEV_KRYPTON_ABS_HUM_4M         [krypton hygrometer]
MEAN_AIR_TEMP_4M                [thermometer]
SDEV_AIR_TEMP_4M                [thermometer]
SOLENT_AIR_TEMP_4M              [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]
MEAN_SOIL_TEMP_INT_3CM          [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]
GRAV_SOIL_WATER_CONTENT_3CM     [scale]
REL_HUM_4M                      [humidity sensor]
BOLE_TEMP_2MM                   [thermocouple]
BOLE_TEMP_4CM                   [thermocouple]
BOLE_TEMP_8CM                   [thermocouple]
BOLE_TEMP_12CM                  [thermocouple]
BOLE_TEMP_158MM                 [thermocouple]
HAZEL_BOLE_TEMP_2MM             [thermocouple]
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SNOW_IRT_TEMP	[infrared thermometer]
SNOW_TEMP_6CM	[thermocouple]
SNOW_TEMP_12CM	[thermocouple]
SNOW_TEMP_18CM	[thermocouple]
SNOW_TEMP_24CM	[thermocouple]
SNOW_TEMP_30CM	[thermocouple]
SNOW_TEMP_36CM	[thermocouple]
SURF_PRESS	[barometer]
DATA_QUALITY_FLAG	[Supplied by Investigator.]
COMMENTS	[Supplied by Investigator.]
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-9OA-FLXTR	SSA-9OA-FLXTR	None	None	None	None
SUB_SITE	9TF01-UNS01	9TF01-UNS01	None	None	None	None
DATE_OBS	12-OCT-93	31-DEC-94	None	None	None	None
TIME_OBS	0	2344	None	None	None	None
SENSIBLE_HEAT_FLUX_BELOW_CNPY	-4573	8845.4	-999	None	None	Blank
LIC_LATENT_HEAT_FLUX_4M	-299.61	3162	-999	None	None	Blank
KRYPTON_LATENT_HEAT_FLUX_4M	-8032	3431	-999	None	None	Blank
NET_RAD_10CM	-6.101	225.43	-999	None	None	Blank
SOIL_HEAT_FLUX_3CM_1	-14.24	98.4	-999	None	None	Blank
SOIL_HEAT_FLUX_3CM_2	-17.04	92.9	-999	None	None	Blank
SOIL_HEAT_FLUX_3CM_3	-13.98	84.9	-999	None	None	Blank
SOIL_HEAT_FLUX_3CM_4	-13.26	68.39	-999	None	None	Blank
SOIL_HEAT_FLUX_3CM_5	-15.34	107.2	-999	None	None	Blank
SOIL_HEAT_FLUX_3CM_6	-15.34	263.6	-999	None	None	Blank
SOIL_HEAT_FLUX_3CM_7	-14.76	77.5	-999	None	None	Blank
SOIL_HEAT_FLUX_3CM_8	-10.66	81.8	-999	None	None	Blank
SOIL_HEAT_FLUX_3CM_9	-12.56	35.77	-999	None	None	Blank
MEAN_SOIL_HEAT_FLUX_3CM	-3103.3	79.9	-999	None	None	Blank
SOIL_HEAT_FLUX_8CM	-10.93	63.64	-999	None	None	Blank
SOIL_HEAT_STORAGE_RATE	-45.74	64.41	-999	None	None	Blank
SURFACE_SOIL_HEAT_FLUX	-3107.5	86.068	-999	None	None	Blank
CO2_FLUX_BELOW_CNPY	-1461.3636	109.9614	-999	None	None	Blank
MEAN_CO2_CONC_4M	-14.465	553.94	-999	None	None	Blank
SDEV_CO2_CONC_4M	0	79.62	None	None	None	Blank
BOWEN_RATIO_4M	-6572.9	8628.6	-999	None	None	Blank
KINEM_MOMENT_FLUX_4M	-144	64.4	-999	None	None	Blank
DOWN_PPFD_10CM	-.19505	2838.1	-999	None	None	Blank
WIND_DIR_4M	-2.199	350.79	-999	None	None	Blank

WIND_SPEED_4M	0	49.732	-999	None	None	Blank
FRICTION_VEL_4M	.0008	3.6232	-999	None	None	Blank
WIND_SPEED_RESULTANT_VECTOR_4M	0	1.583	-999	None	None	Blank
WIND_DIR_RESULTANT_4M	0	359.92	-999	None	None	Blank
MEAN_U_WIND_SPEED_4M	.01	1.83	-999	None	None	Blank
MEAN_W_WIND_SPEED_4M	-.11	.25	-999	None	None	Blank
VAR_W_WIND_SPEED_4M	0	12.847	-999	None	None	Blank
SDEV_W_WIND_SPEED_4M	.01	10.77	None	None	None	Blank
ABS_HUM_4M	.9719	16.889	-999	None	None	Blank
MEAN_LIC_ABS_HUM_4M	-.204	25.875	-999	None	None	Blank
MEAN_KRYPTON_ABS_HUM_4M	-2.364	56.38	None	None	None	Blank
SDEV_LIC_ABS_HUM_4M	0	1.992	None	None	None	Blank
SDEV_KRYPTON_ABS_HUM_4M	.01	21.1	None	None	None	Blank
MEAN_AIR_TEMP_4M	-11.447	28.507	-999	None	None	Blank
SDEV_AIR_TEMP_4M	.017	19.85	None	None	None	Blank
SOLENT_AIR_TEMP_4M	-6.948	29.316	-999	None	None	Blank
SOIL_TEMP_2CM	-3.69	17.78	-999	None	None	Blank
SOIL_TEMP_5CM	-3.061	15.69	-999	None	None	Blank
SOIL_TEMP_10CM	-2.867	15.23	-999	None	None	Blank
SOIL_TEMP_20CM	-2.205	14.17	-999	None	None	Blank
SOIL_TEMP_50CM	-.965	12.1	-999	None	None	Blank
SOIL_TEMP_100CM	-.227	10.21	-999	None	None	Blank
MEAN_SOIL_TEMP_INT_3CM	-2.563	19.985	-999	None	None	Blank
SOIL_WATER_POTENT_3CM	.0272	699.9	-999	None	None	Blank
SOIL_WATER_POTENT_6CM	.0292	699.9	-999	None	None	Blank
SOIL_WATER_POTENT_46CM	.0261	36.21	-999	None	None	Blank
GRAV_SOIL_WATER_CONTENT_3CM	.065	.307	-999	None	None	Blank
REL_HUM_4M	-129.47	98.459	-999	None	None	Blank
BOLE_TEMP_2MM	-29.275	32.34	-999	None	None	Blank
BOLE_TEMP_4CM	-29.392	27.413	-999	None	None	Blank
BOLE_TEMP_8CM	-29.313	26.185	-999	None	None	Blank
BOLE_TEMP_12CM	-29.173	25.689	-999	None	None	Blank
BOLE_TEMP_158MM	-29.47	28.548	-999	None	None	Blank
HAZEL_BOLE_TEMP_2MM	0	27.344	-999	None	None	Blank
SNOW_IRT_TEMP	-35.627	132.57	-999	None	None	Blank
SNOW_TEMP_6CM	-7.998	29.94	-999	None	None	Blank
SNOW_TEMP_12CM	-9.293	29.301	-999	None	None	Blank
SNOW_TEMP_18CM	-12.511	29.008	-999	None	None	Blank
SNOW_TEMP_24CM	-15.011	28.847	-999	None	None	Blank
SNOW_TEMP_30CM	-18.131	28.774	-999	None	None	Blank
SNOW_TEMP_36CM	-23.509	28.627	-999	None	None	Blank
SURF_PRESS	59.95	95.97	-999	None	None	Blank
DATA_QUALITY_FLAG	N/A	N/A	None	None	None	Blank
COMMENTS	N/A	N/A	None	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	18-AUG-99	18-AUG-99	None	None	None	None

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------------------------------------------------------------------------------
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.
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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_BELOW_CNPY,
LIC_LATENT_HEAT_FLUX_4M,KRYPTON_LATENT_HEAT_FLUX_4M,NET_RAD_10CM,
SOIL_HEAT_FLUX_3CM_1,SOIL_HEAT_FLUX_3CM_2,SOIL_HEAT_FLUX_3CM_3,
SOIL_HEAT_FLUX_3CM_4,SOIL_HEAT_FLUX_3CM_5,SOIL_HEAT_FLUX_3CM_6,
SOIL_HEAT_FLUX_3CM_7,SOIL_HEAT_FLUX_3CM_8,SOIL_HEAT_FLUX_3CM_9,
MEAN_SOIL_HEAT_FLUX_3CM,SOIL_HEAT_FLUX_8CM,SOIL_HEAT_STORAGE_RATE,
SURFACE_SOIL_HEAT_FLUX,CO2_FLUX_BELOW_CNPY,MEAN_CO2_CONC_4M,SDEV_CO2_CONC_4M,
BOWEN_RATIO_4M,KINEM_MOMENT_FLUX_4M,DOWN_PPFD_10CM,WIND_DIR_4M,WIND_SPEED_4M,
FRICTION_VEL_4M,WIND_SPEED_RESULTANT_VECTOR_4M,WIND_DIR_RESULTANT_4M,
MEAN_U_WIND_SPEED_4M,MEAN_W_WIND_SPEED_4M,VAR_W_WIND_SPEED_4M,
SDEV_W_WIND_SPEED_4M,ABS_HUM_4M,MEAN_LIC_ABS_HUM_4M,SDEV_LIC_ABS_HUM_4M,
MEAN_KRYPTON_ABS_HUM_4M,SDEV_KRYPTON_ABS_HUM_4M,MEAN_AIR_TEMP_4M,
SDEV_AIR_TEMP_4M,SOLENT_AIR_TEMP_4M,SOIL_TEMP_2CM,SOIL_TEMP_5CM,
SOIL_TEMP_10CM,SOIL_TEMP_20CM,SOIL_TEMP_50CM,SOIL_TEMP_100CM,
MEAN_SOIL_TEMP_INT_3CM,SOIL_WATER_POTENT_3CM,SOIL_WATER_POTENT_6CM,
SOIL_WATER_POTENT_46CM,GRAV_SOIL_WATER_CONTENT_3CM,REL_HUM_4M,BOLE_TEMP_2MM,
BOLE_TEMP_4CM,BOLE_TEMP_8CM,BOLE_TEMP_12CM,BOLE_TEMP_158MM,HAZEL_BOLE_TEMP_2MM,
SNOW_IRT_TEMP,SNOW_TEMP_6CM,SNOW_TEMP_12CM,SNOW_TEMP_18CM,SNOW_TEMP_24CM,
SNOW_TEMP_30CM,SNOW_TEMP_36CM,SURF_PRESS,DATA_QUALITY_FLAG,COMMENTS,
CRTFCN_CODE,REVISION_DATE
'SSA-9OA-FLXTR','9TF01-UNS01',01-JUN-94,0,2.823,8.352,,0.0,19.69,16.87,18.27,
16.64,22.21,22.27,16.6,13.89,14.53,17.886,21.53,-3.906,13.979,1.8751,372.23,,
.338,-.01,0.0,174.12,.077,.1007,.075,1.064,.24,.05,.005,,6.0113,8.425,,,,
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19.352,,18.776,11.61,10.13,9.65,8.43,6.581,4.878,13.845,.0312,.0315,.0291,
.223,36.096,20.391,20.443,19.513,19.942,20.314,0.0,16.586,18.392,18.203,
18.355,18.297,18.353,18.44,94.9,'','','CPI',18-AUG-99
'SSA-9OA-FLXTR','9TF01-UNS01',01-JUN-94,30,1.629,30.787,,0.0,18.37,15.83,
17.19,15.61,20.63,20.93,15.99,13.21,13.84,16.844,20.39,-.953,15.892,3.6043,
370.64,,.053,-.002,0.0,131.22,.008,.0329,.008,85.382,.14,.02,.007,,5.9139,
8.239,,,,19.167,,18.691,11.51,10.12,9.66,8.47,6.58,4.88,13.795,.0313,.0315,
.029,.223,35.878,20.233,20.34,19.73,20.018,20.261,0.0,16.567,18.197,18.024,
18.197,18.113,18.184,18.267,94.91,'','','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. The soil heat storage rate is the rate of change of heat storage in the 0-3 cm surface layer calculated from the gravimetric soil water content and the mean integrated soil temperature. The soil surface heat flux density is the sum of the 3-cm soil heat flux and the soil heat storage rate.

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
See Section 10.2.1.

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 the University of British Columbia (UBC) (Z. Nesic). Relatively little data were missing in 4-m measurements in 1994 and 39 m in 1996.

There are several sources of error in the measurements. These are coded, based on field notes, in the COMMENTS column. The following are the definitions of these codes:

```
P  = all sensors "parked" in a tower shelter for protection
     (e.g. high winds).
Z  = zero check on LI-COR
B  = daily backup of data files
C  = computer crash
S  = starting time of a run, if not on the half hour
     (e.g. S18:50:30).
RK = rotated krypton 90 degrees
CK = cleaned krypton
SK = suspect snow on krypton
SS = suspect snow on sonic anemometer/thermometer
AP = adjusted LI-COR sampling pump
TC = zero gas tank change
RT = repair zero gas tank
PF = power failure
PP = suspect pulp and paper mill influence
CS = communication problem with sonic anemometer/thermometer
ZE = data compression error due to incorrect CPU time
```

The DATA_QUALITY_FLAG column contains four data quality flags:

- Flag one is for the sonic anemometer/thermometer. The low status of this flag (0) indicates problems with the anemometer/thermometer and its built-in Analog to Digital (A/D) card. This affected all measurements contained in this data file.
- Flag two is for the closed-path analyzer (LI-COR6262) in measuring CO_2. The low status of this flag indicates that the analyzer was not performed properly. The measurements of MEAN_CO2_CONC_4M, SDEV_CO2_CONC_4M, and CO2_FLUX_BELOW_CNPY are of poor quality.
- Flag three is for the closed-path analyzer (LI-COR6262) in measuring H_2O. The low status of this flag indicates that the analyzer was not performed properly. The measurements of MEAN_LIC_ABS_HUM_4M, SDEV_LIC_ABS_HUM_4M, and LIC_LATENT_HEAT_FLUX_4M are of poor quality.
- Flag four is for the open-path analyzer (krypton). The low status of this flag indicates problems with this analyzer, mostly as a result of precipitation landing on the sensor. Measurements made with this analyzer, including MEAN_KRYPTON_ABS_HUM_4M, SDEV_KRYPTON_ABS_HUM_4M, and KRYPTON_LATENT_HEAT_FLUX_4M are poor in quality. Some runs with this flag set high might also have be interfered by precipitation. Users should therefore be careful in interpreting the measurements made with this analyzer. Users are also advised to use MEAN_KRYPTON_ABS_HUM_4M only as the absolute humidity measurement, because this type of open-path analyzers (K20) can have substantial zero drift over a short time period.

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

See Section 10.2.1.

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.

14.2 Software Access

None given.

15. Data Access

The SSA-OA understory 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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17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

A/D - Analog to Digital
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
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
WPL - Webb, Pearman, and Leuning (1980) corrections

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13. ABSTRACT *(Maximum 200 words)*

The BOREAS TF-1 team collected energy, carbon dioxide, and momentum flux data under the canopy along with meteorological and soils data at the BOREAS SSA-OA site from mid-October to mid-November of 1993 and throughout all of 1994. The data are available in tabular ASCII files.

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