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

Forrest G. Hall and Karl Huemmrich, Editors

Volume 195

BOREAS TF-3 NSA-OBS Tower Flux, Meteorological, and Soil Temperature Data

S. Wofsy, M. Goulden, and D. Sutton

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

October 2000

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BOREAS TF-3 NSA-OBS Tower Flux, Meteorological, and Soil Temperature Data

Steven Wofsy, Mike Goulden, Doug Sutton

Summary

The BOREAS TF-3 team collected tower flux, surface meteorological, and soil temperature data at the BOREAS NSA-OBS site continuously from the March 1994 through October 1996. The data are available in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS TF-03 NSA-OBS Tower Flux, Meteorological, and Soil Temperature Data

1.2 Data Set Introduction

Continuous eddy-correlation flux measurements of sensible heat, latent heat, CO_2, and momentum fluxes were made at the BOReal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA)-Old Black Spruce (OBS) site from March 1994 to October 1996.

1.3 Objective/Purpose

The principal objective was to determine directly the net ecosystem exchange of CO_2 and the surface energy budget over diurnal, seasonal, and annual time scales and to couple these observations with a comprehensive characterization of the physical environment (Photosynthetically Active Radiation (PAR), soil temperature, etc.). In addition, CO_2 and water vapor concentration throughout the forest column were measured. This suite of long-term measurements should provide information to assess the effect of seasons and seasonal changes on the carbon balance of the forest. Determination of the boundary layer CO_2 concentration anomaly can also be determined, and thus the effect of the forest on the boundary layer CO_2 concentration can be studied.

1.4 Summary of Parameters

Latent heat flux, sensible heat flux, CO_2 flux, momentum flux, CO_2 profile, water vapor profile, air temperature profile, net radiation, incident Photosynthetic Photon Flux Density (PPFD), reflected PPFD, below-canopy PPFD, wind speed and direction, soil temperature, precipitation amount.

1.5 Discussion

Eddy-correlation flux measurements for CO_2 and H_2O were made at the northern black spruce site from the late summer of 1993 through the fall of 1996. The principal objective was to directly determine the net ecosystem exchange of CO_2 and the surface energy budget over diurnal, seasonal, and annual time scales and to couple these observations with a comprehensive characterization of the physical environment (PAR, soil temperature, etc.). A low-power automated array was installed to measure eddy fluxes and forest column content of CO_2, sensible heat, and water vapor; soil temperatures and moisture; and incident and intercepted PAR. The system was operated continuously from installation in September 1993 to October 1994 (with some gaps). Additionally, measurements of the flux of CO_2 from the soil were made during the summer of 1994 using an array of automated open chambers. Among other things, these long-term measurements should allow assessment of the importance of winter respiration and assimilation during transitional periods to the annual carbon balance of the boreal forest.

1.6 Related Data Sets

Tower flux measurements made at other sites:
BOREAS TF-08 NSA-OJP Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-09 SSA-OBS Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-10 NSA-Fen Flux, Meteorological, and Soil Temperature Data
BOREAS TF-10 NSA-YJP Flux, Meteorological, and Soil Temperature Data

Other measurements made at the NSA-OBS site:
BOREAS TE-06 Allometry Data
BOREAS TE-09 NSA Photosynthetic Response Data
BOREAS TGB-01 NSA CH4 and CO2 Chamber Flux Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

Wofsy, S.C., M.L. Goulden, B.C. Daube, J.W. Munger, S.M. Fan, D.J. Sutton, A. Bazzaz
Harvard University Cambridge, MA

2.2 Title of Investigation

Eddy Correlation Flux Measurements of CO_2 for BOREAS

2.3 Contact Information

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3. Theory of Measurements

Most investigations of forest CO_2 exchange have relied on models to extrapolate short-term gas-exchange measurements made with small chambers. This approach has contributed greatly to understanding, but uncertainties are inevitable when small-scale observations are aggregated to whole ecosystems, and short-term data to annual balances. An alternative approach, used here, was to use the eddy covariance technique over a complete growing season to directly measure the net exchange of CO_2 between the atmosphere and a patch of forest several hectares in size.

4. Equipment

4.1 Sensor/Instrument Description

4.1.1 Collection Environment

The measurements were made at a remote (50 km from the nearest town and 5 km from the nearest road), old (70-90 years) black spruce site. The coverage was relatively homogeneous, and the trees were approximately 10 m tall. The ground cover was primarily feather moss mixed with some lower-level areas of sphagnum bog. The data were collected continuously through several years; therefore, the full range of boreal weather conditions was experienced, including temperature ranges between 30 and -40 °C.

4.1.2 Source/Platform

The instruments were supported on a 31-m-tall Rohn 25-G triangular cross-section communications tower.

Summary of Eddy Correlation System used by Harvard:

Instrument	Notes
Vertical and horizontal velocity sensor	3-axis ATI sonic with Kaimel probe
Temperature sensor	ATI virtual temperature
Moisture sensor	LiCor 6262 Infrared Gas Analyzer (IRGA)
CO_2 sensor	LiCor 6262 IRGA
Sensor height above ground	29 m
Sampling rate	4 Hz
Vertical wind speed	ATI sonic anemometer
Horizontal wind speed	ATI sonic anemometer -- Met One spinning cup
Wind direction	ATI sonic anemometer -- Met One sensor
Temperature	ATI sonic anemometer
CO_2	LiCor 6262
H_2O	LiCor 6262
Inlet Filter	Gelman Zeflour 3 µm pores, 4 x 50 mm diameter
Tubing	0.64" ID high-density polyethylene, 50 meters long (replaced May 1996 with PFA Teflon)
Pumps	KNF Neuberger K022 ANA pumps
Data logger	Campbell Scientific CR10
Pressure and flow controllers	MKS Instruments

4.1.3 Source/Platform Mission Objectives

The tower was erected to support instruments above the forest canopy to collect flux data at NSA-OBS.

4.1.4 Key Variables

Eddy-correlation measurements of latent heat flux, sensible heat flux, CO_2 flux, and momentum flux. Profiles of CO_2, water vapor, and air temperature. Incident, reflected, and below-canopy PPFD. Wind speed and direction, soil temperature, precipitation.

4.1.5 Principles of Operation

Sonic Anemometer: Three-dimensional orthogonal wind velocities (u, v, and w) and virtual temperature (Tv) were measured with a sonic anemometer (Applied Technology, Boulder, CO). The path length between transducers was 0.15 m. The sensor software corrected for transducer shadowing effects (see Kaimal et al., 1990). Virtual temperature heat flux was converted to sensible heat flux using algorithms described by Kaimal and Gaynor (1991) and Schotanus et al. (1983).

Infrared Absorption Spectrometer: Water vapor and CO_2 concentrations were measured with an open-path infrared absorption spectrometer.

4.1.6 Sensor/Instrument Measurement Geometry

The sonic anemometer was located at a height of 29 m on a 31-m triangular cross-section radio tower (Rohn 25-G). The tubing inlet for the air sample was located 0.5 m below the sonic anemometer. The LI-COR sensors were placed in a climate-controlled hut 20 m northeast of the tower. The air was drawn down the tower at 18 standard liters per minute. The air was passed through a thermostated block to stabilize the temperature and drawn through the LI-COR at 4 standard liters per minute. Pressure was controlled in the cell of the LI-COR at 53 kPa.

Air temperature profiles were measured at 27.0 m, 8.2 m, and 1.15 m above ground level. Relative humidity was measured at 27.0 m. Wind speed and direction were measured at 29.6 m. The sonic anemometer was mounted at 29 m. Under-canopy PPFD sensor arrays were placed at ground level. Soil temperature probes were placed at depths of 1 cm, 5 cm, 10 cm, 20 cm, 50 cm, and 100 cm. Soil heat flux plates were at depths of 1 cm, 5 cm, and 10 cm.

4.1.7 Manufacturer of Sensor/Instrument

Sonic anemometer
Applied Technologies
6395 Gunpark
Boulder, CO.

CO_2 and H_2O sensor
LI-COR
P.O. Box 4425
Lincoln, NE.

Data logging systems
Campbell Scientific Instruments
P.O. Box 551
Logan, UT 84321

Pressure and Flow Control
MKS Instruments
Andover, MA.

4.2 Calibration

4.2.1 Specifications

- Sonic anemometer: Supplied by the manufacturer. Instrument zeros and maintenance performed at least twice per year.
- CO_2 sensor: Calibrated every 3 hours by standard addition of 4% CO_2 at 40 and 80 standard milliliters per minute for 2 minutes 15-m below the sample inlet on tower. Zero datum for the LI-COR IRGA was achieved by passing sample air through a column of soda lime for 2 minutes.
- H_2O sensor: Calibrated every few months using a LI-COR dew point generator. Calibration was checked by comparison with a Vaisala probe on the tower. Zero information was recorded every 3 hours by passing sample air through a column of magnesium perchlorate for 2 minutes.
- CO_2 concentration calibration: Used an independent LI-COR 6262 IGA and two span gases (~340 ppm and ~420 ppm). These gas samples are traceable to the 1993 Scripps-World Meteorological Organization (WMO) standard. Calibrations were done every 3 hours by passing each of the gases through the LI-COR IGA at 1.25 standard liters per minute for 2 minutes. Zero information was achieved by the same method as that used for the eddy CO_2-sensor.

4.2.1.1 Tolerance

Not known.

4.2.2 Frequency of Calibration

- Sonic anemometer: Instrument zeros and maintenance performed at least twice per year.
- CO_2 sensor: Calibrated every 3 hours by standard addition of 4% CO_2 at 40 and 80 standard milliliters per minute for 2 minutes 15-m below the sample inlet on tower.
- H_2O sensor: Calibrated every few months using LI-COR dew point generator. Zero information is recorded every 3 hours by passing sample air through a column of magnesium perchlorate for 2 minutes.
- CO_2 concentration calibration: Calibrations are done every 3 hours by passing each of the gas samples through the LI-COR at 1.25 standard liters per minute for 2 minutes.

4.2.3 Other Calibration Information

Not known.

5. Data Acquisition Methods

Data for flux measurements were continuously recorded at 4 Hz while other parameters were recorded at 0.5 Hz. The data were stored on a PC and collected twice per week. The delay time between the wind speed and concentration measurement was calculated at 5.5 seconds. The time constant for response time of the instrument to a change in the mixing ratio of the air sample was determined to be 0.6 seconds for CO_2 and 1.25 seconds for H_2O. The difference in time was due to adsorption of H_2O to the tubing. The response-time corrections typically were 5 to 10% during the day and 15 to 25% at night. An averaging time of 30 minutes was used and a linear least-squares regression was used to detrend the flux data.

6. Observations

6.1 Data Notes

None available.

6.2 Field Notes

Notable data gaps occurred in May 1994, when an error was introduced into the data acquisition code; August 1994, when the sonic anemometer was damaged twice by lightning; fall 1994, when the generator failed repeatedly; June 1995, when computer disks failed twice; and November 1995, when the sonic anemometer failed with the onset of cold temperatures.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

All data were collected at the BOREAS NSA-OBS site. The North American Datum of 1983 (NAD83) coordinates of the site are latitude 55.88007° N, longitude 98.48139° W, and elevation of 259 m.

7.1.2 Spatial Coverage Map

Not applicable.

7.1.3 Spatial Resolution

The data represent point source measurements taken at the given location. The location and size of the footprint from which the measurements were made varied with ambient meteorological conditions.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

Measurements are available from 16-Mar-1994 through 31-Oct-1996. Valid measurements are available 72% of the time. Notable gaps occurred in May 1994, August 1994, fall 1994, June 1995, and November 1995.

7.2.2 Temporal Coverage Map

All data were collected at the NSA-OBS site.

7.2.3 Temporal Resolution

Data for flux measurements were continuously recorded at 4 Hz while other parameters were recorded at 0.5 Hz. The delay time between the wind speed and concentration measurement was calculated at 5.5 seconds. The time constant for response time of the instrument to a change in the mixing ratio of the air sample was determined to be 0.6 seconds for CO_2 and 1.25 seconds for H_2O. The difference in time was due to adsorption of H_2O to the tubing. The response-time corrections typically were 5 to 10% during the day and 15 to 25% at night. An averaging time of 30 minutes was used and a linear least-squares regression was used to detrend the flux data.

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
CO2_FLUX_ABV_CNPY
CO2_CONC_ABV_CNPY
CO2_STORAGE
DOWN_PPFD_ABV_CNPY
DOWN_PPFD_BELOW_CNPY
WIND_DIR_MAG_ABV_CNPY
WIND_SPEED_ABV_CNPY
FRICTION_VELOC_ABV_CNPY
AIR_TEMP_ABV_CNPY
AIR_TEMP_10M
AIR_TEMP_2M
SOIL_TEMP_5CM_1
SOIL_TEMP_10CM_1
SOIL_TEMP_20CM_1
SOIL_TEMP_50CM_1
SOIL_TEMP_100CM_1
SOIL_TEMP_5CM_2
SOIL_TEMP_10CM_2
SOIL_TEMP_20CM_2
SOIL_TEMP_50CM_2
SOIL_TEMP_100CM_2
VAPOR_PRESS_ABV_CNPY
RAIN_RATE
```

MONIN_OBUKHOV_LENGTH
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.
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_STORAGE	The storage term of carbon dioxide under the eddy flux system.
DOWN_PPFD_ABV_CNPY	The incoming photosynthetic photon flux density measured above the canopy.
DOWN_PPFD_BELOW_CNPY	The downward photosynthetic photon flux density measured under the canopy.
WIND_DIR_MAG_ABV_CNPY	The wind direction measured above the canopy from magnetic north.
WIND_SPEED_ABV_CNPY	The wind speed measured above the canopy.
FRICTION_VELOC_ABV_CNPY	The friction velocity above the canopy.
AIR_TEMP_ABV_CNPY	The air temperature measured above the canopy.
AIR_TEMP_10M	The air temperature measured at 10 meters above the ground.
AIR_TEMP_2M	The air temperature at 2 meters above the ground
SOIL_TEMP_5CM_1	The soil temperature recorded at 5 cm in depth at plot 1.
SOIL_TEMP_10CM_1	The soil temperature recorded at 10 cm in depth at plot 1.
SOIL_TEMP_20CM_1	The soil temperature recorded at 20 cm in depth at plot 1.
SOIL_TEMP_50CM_1	The soil temperature recorded at 50 cm in depth at plot 1.
SOIL_TEMP_100CM_1	The soil temperature recorded at 1 m in depth at

	plot 1.
SOIL_TEMP_5CM_2	The soil temperature recorded at 5 cm in depth at plot 2.
SOIL_TEMP_10CM_2	The soil temperature recorded at 10 cm in depth at plot 2.
SOIL_TEMP_20CM_2	The soil temperature recorded at 20 cm in depth at plot 2.
SOIL_TEMP_50CM_2	The soil temperature recorded at 50 cm in depth at plot 2.
SOIL_TEMP_100CM_2	The soil temperature recorded at 1 m in depth at plot 2.
VAPOR_PRESS_ABV_CNPY	The vapor pressure measured above the canopy.
RAIN_RATE	The rainfall rate measured in a clearing.
MONIN_OBUKHOV_LENGTH	The Monin-Obukhov length.
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]
CO2_FLUX_ABV_CNPY	[micromoles][meter^-2][second^-1]
CO2_CONC_ABV_CNPY	[parts per million]
CO2_STORAGE	[micromoles][meter^-2][second^-1]
DOWN_PPFD_ABV_CNPY	[micromoles][meter^-2][second^-1]
DOWN_PPFD_BELOW_CNPY	[micromoles][meter^-2][second^-1]
WIND_DIR_MAG_ABV_CNPY	[degrees from magnetic North]
WIND_SPEED_ABV_CNPY	[meters][second^-1]
FRICTION_VELOC_ABV_CNPY	[meters][second^-1]
AIR_TEMP_ABV_CNPY	[degrees Celsius]
AIR_TEMP_10M	[degrees Celsius]
AIR_TEMP_2M	[degrees Celsius]
SOIL_TEMP_5CM_1	[degrees Celsius]
SOIL_TEMP_10CM_1	[degrees Celsius]
SOIL_TEMP_20CM_1	[degrees Celsius]
SOIL_TEMP_50CM_1	[degrees Celsius]
SOIL_TEMP_100CM_1	[degrees Celsius]
SOIL_TEMP_5CM_2	[degrees Celsius]
SOIL_TEMP_10CM_2	[degrees Celsius]
SOIL_TEMP_20CM_2	[degrees Celsius]
SOIL_TEMP_50CM_2	[degrees Celsius]
SOIL_TEMP_100CM_2	[degrees Celsius]

VAPOR_PRESS_ABV_CNPY	[kiloPascals]
RAIN_RATE	[millimeters][hour^-1]
MONIN_OBUKHOV_LENGTH	[meters]
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	[Investigator]
TIME_OBS	[Investigator]
SENSIBLE_HEAT_FLUX_ABV_CNPY	[ATI sonic anemometer]
LATENT_HEAT_FLUX_ABV_CNPY	[Infrared Gas Analyzer]
NET_RAD_ABV_CNPY	[Net radiometer]
CO2_FLUX_ABV_CNPY	[Infrared Gas Analyzer]
CO2_CONC_ABV_CNPY	[Infrared Gas Analyzer]
CO2_STORAGE	[Infrared Gas Analyzer]
DOWN_PPFD_ABV_CNPY	[Quantum sensor]
DOWN_PPFD_BELOW_CNPY	[Quantum sensor]
WIND_DIR_MAG_ABV_CNPY	[Met One sensor]
WIND_SPEED_ABV_CNPY	[Met One spinning cup]
FRICTION_VELOC_ABV_CNPY	[ATI sonic anemometer]
AIR_TEMP_ABV_CNPY	[thermocouple]
AIR_TEMP_10M	[thermocouple]
AIR_TEMP_2M	[thermocouple]
SOIL_TEMP_5CM_1	[thermocouple]
SOIL_TEMP_10CM_1	[thermocouple]
SOIL_TEMP_20CM_1	[thermocouple]
SOIL_TEMP_50CM_1	[thermocouple]
SOIL_TEMP_100CM_1	[thermocouple]
SOIL_TEMP_5CM_2	[thermocouple]
SOIL_TEMP_10CM_2	[thermocouple]
SOIL_TEMP_20CM_2	[thermocouple]
SOIL_TEMP_50CM_2	[thermocouple]
SOIL_TEMP_100CM_2	[thermocouple]
VAPOR_PRESS_ABV_CNPY	[thermocouple]
RAIN_RATE	[Infrared Gas Analyzer]
MONIN_OBUKHOV_LENGTH	[ATI sonic anemometer]
CRTFCN_CODE	[Assigned by BORIS]
REVISION_DATE	[Assigned by BORIS]

7.3.5 Data Range

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

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	NSA-OBS-FLXTR	NSA-OBS-FLXTR	None	None	None	None
SUB_SITE	9TF03-FLX01	9TF03-FLX01	None	None	None	None
DATE_OBS	16-MAR-94	31-OCT-96	None	None	None	None
TIME_OBS	0	2330	None	None	None	None
SENSIBLE_HEAT_FLUX_ABV_CNPY	-192.857	661.963	-999	None	None	None
LATENT_HEAT_FLUX_ABV_CNPY	-182.232	514.406	-999	None	None	None
NET_RAD_ABV_CNPY	-77.88	831.6	-999	None	None	None
CO2_FLUX_ABV_CNPY	-17.964	52.586	-999	None	None	None
CO2_CONC_ABV_CNPY	333.035	448.098	-999	None	None	None
CO2_STORAGE	-20.49	12.09	-999	None	None	None
DOWN_PPFD_ABV_CNPY	-41.878	2129.89	-999	None	None	None
DOWN_PPFD_BELOW_CNPY	-23.073	379.72	-999	None	None	None
WIND_DIR_MAG_ABV_CNPY	0	360	-999	None	None	None
WIND_SPEED_ABV_CNPY	.06	12.24	-999	None	None	None
FRICTION_VELOC_ABV_CNPY	.01	1.928	-999	None	None	None
AIR_TEMP_ABV_CNPY	-44.299	36.216	-999	None	None	None
AIR_TEMP_10M	-44.81	37.268	-999	None	None	None
AIR_TEMP_2M	-45.071	37.31	-999	None	None	None
SOIL_TEMP_5CM_1	-10.382	33.19	-999	None	None	None
SOIL_TEMP_10CM_1	-4.971	19.37	-999	None	None	None
SOIL_TEMP_20CM_1	-1.686	12.582	-999	None	None	None
SOIL_TEMP_50CM_1	-1.003	6.065	-999	None	None	None
SOIL_TEMP_100CM_1	-.196	3.932	-999	None	None	None
SOIL_TEMP_5CM_2	-22.327	34.565	-999	None	None	None
SOIL_TEMP_10CM_2	-24.914	30.136	-999	None	None	None
SOIL_TEMP_20CM_2	-13.726	20.396	-999	None	None	None
SOIL_TEMP_50CM_2	-4.872	10.316	-999	None	None	None
SOIL_TEMP_100CM_2	-.958	2.112	-999	None	None	None
VAPOR_PRESS_ABV_CNPY	.0423	2.8647	-999	None	None	None
RAIN_RATE	0	6.6	-999	None	None	None
MONIN_OBUKHOV_LENGTH	-776.636	2048890	-999	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	05-FEB-98	05-FEB-98	None	None	None	None

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

```
Below Detect Limit -- The value that indicates parameter values below the
                      instruments detection limits.  This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the analysis personnel determined
                      that the parameter value was below the detection
                      limit of the instrumentation.
Data Not Cllctd    -- This value indicates that no attempt was made to
                      determine the parameter value.  This usually
                      indicates that BORIS combined several similar but
                      not identical data sets into the same data base table
                      but this particular science team did not
                      measure that parameter.

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

7.4 Sample Data Record

The following are wrapped versions of data 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,CO2_FLUX_ABV_CNPY,
CO2_CONC_ABV_CNPY,CO2_STORAGE,DOWN_PPFD_ABV_CNPY,DOWN_PPFD_BELOW_CNPY,
WIND_DIR_MAG_ABV_CNPY,WIND_SPEED_ABV_CNPY,FRICTION_VELOC_ABV_CNPY,
AIR_TEMP_ABV_CNPY,AIR_TEMP_10M,AIR_TEMP_2M,SOIL_TEMP_5CM_1,SOIL_TEMP_10CM_1,
SOIL_TEMP_20CM_1,SOIL_TEMP_50CM_1,SOIL_TEMP_100CM_1,SOIL_TEMP_5CM_2,
SOIL_TEMP_10CM_2,SOIL_TEMP_20CM_2,SOIL_TEMP_50CM_2,SOIL_TEMP_100CM_2,
VAPOR_PRESS_ABV_CNPY,RAIN_RATE,MONIN_OBUKHOV_LENGTH,CRTFCN_CODE,REVISION_DATE
'NSA-OBS-FLXTR','9TF03-FLX01',15-JUL-94,30,3.587,26.018,33,.185,347.351,
.77,172.99,28.346,5,3.81,.385,20.139,20.359,20.506,18.404,13.674,6.409,.169,
-.184,18.183,16.746,14.714,2.87,-.317,1.2031,0,-1956,'CPI',05-FEB-98
'NSA-OBS-FLXTR','9TF03-FLX01',15-JUL-94,100,-6.205,17.952,-3.96,.826,347.514,
1.04,112.326,12.539,16,3.66,.356,19.7,19.809,19.773,17.373,13.338,6.47,.213,-.14,
17.519,16.193,14.454,2.911,-.317,1.2063,0,687.611,'CPI',05-FEB-98
```

8. Data Organization

8.1 Data Granularity

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

8.2 Data Format

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

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

9. Data Manipulations

9.1 Formulae

None.

9.1.1 Derivation Techniques and Algorithms

None.

9.2 Data Processing Sequence

9.2.1 Processing Steps

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

The sonic anemometer developed problems with spiking occasionally, caused either by precipitation or by malfunctioning transducers. Processing code was adapted to determine the number of spikes in each interval and to recalculate the turbulent fluxes after filtering out spikes.

9.3.2 Calculated Variables

None.

9.4 Graphs and Plots

None.

10. Errors

10.1 Sources of Error

Errors in flux measurements may be associated with wind from behind the tower, calm conditions, and the damping of high-frequency fluctuations. The sonic anemometer developed problems with spiking occasionally, caused either by precipitation or by malfunctioning transducers.

10.2 Quality Assessment

10.2.1 Data Validation by Source

Raw flux data were examined for errors associated with wind from behind the tower, calm conditions, and the damping of high-frequency fluctuations, and for intervals with malfunctioning instruments. These periods were excluded or the errors were corrected.

10.2.2 Confidence Level/Accuracy Judgment

None given.

10.2.3 Measurement Error for Parameters

None given.

10.2.4 Additional Quality Assessments

None given.

10.2.5 Data Verification by Data Center

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

11. Notes

11.1 Limitations of the Data

None given.

11.2 Known Problems with the Data

CO_2 fluxes may be underestimated when the friction velocity is less than 0.2 m/sec. The closed-path IRGA and long sampling tube resulted in an underestimation of water vapor and CO_2 flux because of the damping of high-frequency fluctuations.

11.3 Usage Guidance

None given.

11.4 Other Relevant Information

None given.

12. Application of the Data Set

This suite of long-term measurements should provide information to assess the effect of seasons and seasonal changes on the carbon balance of the forest. Determination of the boundary layer CO_2 concentration anomaly can also be determined, and thus the effect of the forest on the boundary layer CO_2 concentration can be studied.

13. Future Modifications and Plans

Under separate funding, flux data continued to be collected beyond 31-Oct-1996. Contact personnel at Harvard University about these data.

14. Software

14.1 Software Description

None given.

14.2 Software Access

None given.

15. Data Access

The TF-03 NSA-OBS 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

LI-COR 1991. LI-6262 CO_2/H_2O analyzer operating and service manual. Publ. 9003-59, Lincoln, NE.

17.2 Journal Articles and Study Reports

Goulden, M.L., B.C. Daube, S.M. Fan, D.J. Sutton, A. Bazzaz, J.W. Munger, and S.C. Wofsy. 1997. Physiological responses of a black spruce forest to weather. Journal of Geophysical Research 102(D24):28,987-28,996.

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

Kaimal, J.C., J.E. Gaynor, H.A. Zimmerman, and G.A. Zimmerman. 1990. Minimizing flow distortion errors in a sonic anemometer. Boundary Layer Meteorology. 53:103-115.

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.

Schotanus, P., F.T.M. Nieuwstadt, and H.A.R. De Bruin. 1983. Temperature measurement with a sonic anemometer and its application to heat and moisture fluxes. Boundary-Layer Meteorology. 26: 81-93.

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.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

```
ASCII   - American Standard Code for Information Interchange
BOREAS  - BOReal Ecosystem-Atmosphere Study
BORIS   - BOREAS Information System
CD-ROM  - Compact Disk-Read-Only Memory
DAAC    - Distributed Active Archive Center
EOS     - Earth Observing System
EOSDIS  - EOS Data and Information System
GIS     - Geographic Information System
GMT     - Greenwich Mean Time
GSFC    - Goddard Space Flight Center
HTML    - HyperText Markup Language
IRGA    - Infrared Gas Analyzer
NAD83   - North American Datum of 1983
NASA    - National Aeronautics and Space Administration
NSA     - Northern Study Area
OBS     - Old Black Spruce
OJP     - Old Jack Pine
ORNL    - Oak Ridge National Laboratory
PANP    - Prince Albert National Park
PAR     - Photosynthetically Active Radiation
PPFD    - Photosynthetic Photon Flux Density
SSA     - Southern Study Area
TE      - Terrestrial Ecology
TF      - Tower Flux
TGB     - Trace Gas Biogeochemistry
URL     - Uniform Resource Locator
WMO     - World Meteorological Organization
YJP     - Young Jack Pine
```

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Also, cite the BOREAS CD-ROM set as:

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

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13. ABSTRACT *(Maximum 200 words)*

The BOREAS TF-3 team collected tower flux, surface meteorological, and soil temperature data at the BOREAS NSA-OBS site continuously from the March 1994 through October 1996. The data are available in tabular ASCII files.

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

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