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

Forrest G. Hall and Karl Huemmrich, Editors

Volume 202

BOREAS TF-7 SSA-OBS Tower Flux and Meteorological Data

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National Aeronautics and
Space Administration

Goddard Space Flight Center
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BOREAS TF-7 SSA-OBS Tower Flux and Meteorological Data

Elizabeth Pattey, Raymond L. Desjardins

Summary

The BOREAS TF-7 team collected meteorological data as well as energy, carbon dioxide, water vapor, methane, and nitrous oxide flux data at the BOREAS SSA-OBS site. The data were collected from 24-May to 19-Sep-1994. The data are available in tabular ASCII files.

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1. Data Set Overview

1.1 Data Set Identification

BOREAS TF-07 SSA-OBS Tower Flux and Meteorological Data

1.2 Data Set Introduction

Tower-based flux of heat, momentum, H_2O, CO_2, CH_4, and N_2O were measured by eddy-correlation and/or aerodynamic gradient techniques, over the BOReal Ecosystem-Atmosphere Study (BOREAS) Southern Study Area (SSA) Old Black Spruce (OBS) stand, from day of year 144 to 155, 200 to 209, 251 to 261, in 1994.

1.3 Objective/Purpose

The purpose of this study is to determine the contribution of the boreal ecosystem to the greenhouse gas composition of the atmosphere and how this ecosystem responds to environmental conditions.

Specific objectives are the following:

- scaling-up of mass and energy surface fluxes from the local scale to the regional scale (spatial representativeness of tower-based measurements)
- quantification of the effects of ambient conditions and biological processes on gas exchanges in order to carry out a carbon budget of a black spruce stand
- determination of differences by conditional analysis of aircraft and tower data
- intercomparison between tower-based fluxes

1.4 Summary of Parameters

Latent heat flux; sensible heat flux; water vapor flux; fluxes and concentrations of carbon dioxide, methane, and nitrous oxide; momentum flux; net radiation; incident solar radiation; mean and standard deviation of wind speed and direction; friction velocity; mean U and V components of wind speed; standard deviation of the U, V, and W components of the wind speed; mean and standard deviation of specific humidity, vapor pressure, and air temperature.

1.5 Discussion

Tower Flux (TF)-07 surface fluxes were measured by micrometeorological techniques at the BOREAS SSA-OBS tower.

Momentum, CO_2, and sensible and latent heat fluxes were measured using the eddy-correlation technique (EC), while methane and nitrous oxide fluxes were measured using either EC or the aerodynamic-gradient techniques (AG). Several measurement periods of isoprene fluxes by the relaxed eddy-accumulation technique (REA) were carried out in collaboration with Dr. Hal Westberg (Trace Gas Biogeochemistry (TGB)-10).

The measurements were made at 20 m above the ground (about 12 m above the displacement plane). Wind velocities and temperature were measured with a sonic anemometer-thermometer (Kaijo-Denki DAT-310). Sensible heat flux was corrected for water vapor transfer (Schotanus et al., 1983). The sonic anemometer and the intake tubes of the closed-path analyzers were located on a boom 1.65 m long parallel to the soil surface. By rotating and/or moving the boom to one of the two ends of the south side of the tower, the sensors were oriented in the prevalent wind direction. CO_2 and H_2O concentrations were measured in fast-response absolute mode with an infrared gas analyzer (IRGA; LI-COR 6262) equipped with a 4-m-long sampling tube. The flow in the inlet was turbulent, and the signals were time adjusted to maximize the correlation with the vertical wind velocity. The CO_2 fluxes were corrected for density fluctuations associated with water vapor (Webb et al., 1980) and for sensitivity of the IRGA to water vapor, as determined in our laboratory (Pattey et al., 1992). A detailed description of the data acquisition system can be found in Pattey et al., 1995. Methane and nitrous oxide gradients between 16 and 24 m above the ground were measured with tunable diode lasers (Campbell Scientific, TGA). The eddy diffusivity coefficient, K, was calculated based on the measurements from a sonic anemometer. Isoprene fluxes were measured using REA (Pattey et al., 1993). Isoprene concentration analyses were carried out by Dr. Westberg's team (TGB-10). All the fluxes were calculated on a 30-minute basis. Measurements were carried out during the three Intensive Field Campaigns (IFCs) in 1994 between calendar days 144-155 (May-June), 200-209 (July), and 251-261 (September).

1.6 Related Data Sets

BOREAS TF-09 SSA-OBS Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-05 SSA-OJP Tower Flux and Meteorological Data
BOREAS TF-03 NSA-OBS Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-04 SSA-YJP Tower Flux, Meteorological, and Soil Temperature Data
BOREAS TF-11 SSA-Fen Tower Flux and Meteorological Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. Raymond L. Desjardins
Project Leader
Air Quality Group

Dr. Elizabeth Pattey
Research Scientist
Air Quality Group

2.2 Title of Investigation

Areal Estimates of Mass and Energy from a Boreal Forest Biome

2.3 Contact Information

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3. Theory of Measurements

EC provides the most direct measurement of the flux of a gas at the land-atmosphere interface. It provides measurements of gas exchange without disturbing the environment under study and integrates the flux over a mosaic of different sources and sinks. The instantaneous transfer across a horizontal plane per unit area and per unit time is given by $F = WS$, where W is the vertical velocity, and S is the mixing ratio of the gas of interest. Because turbulent transfer is intermittent, it must be averaged over a certain time or distance to obtain a representative sample. The mean flux of a gas over a horizontally homogeneous surface under steady-state conditions is given by $F = \langle W'S' \rangle$, where W' and S' are the fluctuations from their mean. Reasonably stationary conditions, little horizontal advection and no chemical reaction involving the gas of interest within the air column below the measuring system are required for accurate flux measurements. These effects need to be taken into account to minimize flux divergence with height, which can lead to significant errors of surface flux estimates from aircraft-based systems (Desjardins et al., 1992).

4. Equipment

4.1 Sensor/Instrument Description

A three-axis sonic wind anemometer/thermometer from Kaijo Denki Co. (Japan) was used for measuring the fluctuations of the three wind components (U, V, W) and the temperature (T). The sonic is equipped with 90-degree probes and has a 20-cm open-path. The sonic outputs the following signals: U and V at 90°, the horizontal wind speed (U1= SQRT(U2+V2)), and theta the wind angle relative to the sonic position, in addition to W and T.

An IRGA from LI-COR, Inc., model 6262, was used for measuring water vapor and CO_2 fluctuations, equipped with a pressure transducer between the outlet of the sample cell and the pump.

A tunable-diode laser (TDL) from Campbell Scientific equipped with the laser, sample and reference detector was used for measuring CH_4 fluctuations and N_2O fluctuations.

A pyranometer from LI-COR Inc., model LI-200s was used to measure incoming solar radiation.

4.1.1 Collection Environment

Measurements were collected in intervals from late May through mid-September 1994. Over the data collection periods, the low temperatures experienced did not drop below freezing and the high temperatures were not over 27 °C.

4.1.2 Source/Platform

Above-canopy measurements were made from a 23-meter double scaffold walk-up tower.

4.1.3 Source/Platform Mission Objectives

The objectives were to measure energy and momentum fluxes and fluxes of CO_2, CH_4, and N_2O from a boreal black spruce stand and to obtain diurnal patterns of regional fluxes by combining aircraft- and tower-based flux measurements.

4.1.4 Key Variables

Sensible heat flux, latent heat flux, momentum flux, trace gas fluxes of CO_2, CH_4, and N_2O.

4.1.5 Principles of Operation

Three-axis sonic wind anemometer/thermometer from Kaijo Denki:

The ultrasonic anemometer thermometer measurement is based on the characteristics of sound waves in the atmosphere. Sound waves are propagated in air linearly at an essentially constant speed of approximately 340 m/s. Ultrasonic propagating speed in moving air, however, is slightly variable, traveling faster in a tail wind and slower in a head wind. The wind speed is deducted from the duration taken by ultrasonic pulses to travel between two ultrasonic pulse transducer elements facing each other at a fixed distance. Two ultrasonic pulse signals are alternatively emitted in opposite directions. The sound velocity in air fluctuates with temperature, as well as with humidity and atmospheric pressure. Air temperature fluctuations can be measured assuming longer pressure and humidity fluctuating cycles. In fact, humidity fluctuations should be taken into account to correct sensible heat flux as proposed by Schotanus et al. (1983).

IRGA from LI-COR:

Heteroatomic molecules are known to absorb infrared radiation at specific wavelengths; each gas has a specific absorption spectra. Radiation absorption at a given wavelength follows the Beer-Lambert Law, i.e., is a function of the path length of the measuring cell, the extinction coefficient at the specified wavelength, and the molar concentration of the heteroatomic molecule in air. The wavelength for CO_2 absorption shows sensitivity to water vapor that is attenuated by using filters. As the temperature of the cell is measured, the signals can be corrected for density fluctuations due to temperature. To be read in fast-response mode, signals should be linearized and pressure within the measuring cell included in the linearization equation.

TDL from Campbell Scientific:
The trace gas analyzer system (TGAS, Campbell Scientific) measures absolute concentrations of trace gas species by infrared absorption techniques using a TDL source. The TGAS is a fast-response closed-path analyzer, in which absorption of a specific infrared laser line by trace gas molecules (i.e. either methane or nitrous oxide) is detected. The emission lines are selected to minimize the error caused by absorption from interfering species. The laser intensity absorption follows the Beer-Lambert law of attenuation and is a function of the absorption cross-section, the path-length, and the concentration of methane or nitrous oxide molecules. In the TGAS, the laser beam absorption is measured simultaneously in a 155-cm long sample cell and in a 5-cm-long reference cell filled with either 3.05% certified methane or 0.2668% certified nitrous oxide in nitrogen maintained at about 8 kPa. The number of molecules in the sample cell is equal to the known number of molecules in the reference cell multiplied by the ratio of path-lengths between the reference and sample cell and multiplied by the ratio of the wavelength integrated absorbance between the sample and the reference cell. Both cells are maintained at low pressure to limit pressure broadening of methane or nitrous oxide absorption line. The operating temperature of the TGAS diode laser is in the range of 90 K, which is maintained with liquid nitrogen. Most TDLs are very sensitive to vibration.

Pyranometer from LI-COR:
The pyranometer is constituted of thermopiles. It is used to measure incoming solar radiation.

4.1.6 Sensor/Instrument Measurement Geometry

The sonic anemometer and the intake tubes of the closed-path analyzers were located on a boom 1.65 m long, parallel to the soil surface. The boom was mounted on a rotating table to orient the sensors in the prevalent wind direction, and on a sliding carriage to access both ends of the south side of the tower. The infrared CO_2 and H_2O analyzer (IRGA; LI-COR 6262) was located on the 18.7-m-high platform close to the south side of the tower. It was equipped with a 4-m sampling tube. The TDLs were located on the ground. The methane analyzer was located between the tower and the hut and had a 34.5-m-long sampling tube, while the N_2O analyzer was hooked to the ceiling of the hut and had a 61.5-m-long sampling tube. The conditional sampling system was located on the same platform as the IRGA. Methane and nitrous oxide gradients were measured between 16 and 24 m above the ground.

4.1.7 Manufacturer of Sensor/Instrument

Sonic Anemometer:
Kaijo Denki Co.
GENEQ, Inc.
7978 EST, rue Jarry
Montreal, QUE., H1J 1H5

H2O CO2 IRGA and Pyranometer:
LI-COR, Inc.
P.O. Box 4425
Lincoln, NE 68504

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

Fine-Wire Thermocouple:
Campbell Scientific
P.O. Box 551
Logan, UT 84321

Net Radiometer:
Middleton Instruments, Inc.
P.O. Box 442
South Melbourne
Victoria, 3205
Australia

Data Logging System:
Campbell Scientific
P.O. Box 551
Logan, UT 84321

4.2 Calibration

4.2.1 Specifications

The manufacturer calibration of the LI-6262 to establish the linearization functions was done in July 1993. The field calibration of the LI-6262 was done by removing the offsets on the CO_2 and H_2O signals by passing nitrogen through the reference and sample cells, and by adjusting the gain on CO_2 channel by passing known CO_2 concentration in dry air and by passing known water vapor concentration in air to adjust the H_2O channel. The CO_2 standard was cross-referenced with BOREAS standards.

During IFC-1 and -2, a 10-liter bag was filled with ambient air and connected via a dewpoint hygrometer to the sample cell of the LI-6262. During IFC-3, the LI-610 dewpoint generator was used to produce air at known water vapor concentration.

The sonic anemometer was factory calibrated, except for the temperature, for which a linear correction function was established after IFC-3 in Ottawa against another sonic anemometer. The other signals were well calibrated.

Calibration of the TDLs: the reference cell has a known methane or nitrous oxide certified concentration flowing through it, and the signal is compensated for pressure variation, although the pressure is maintained at a steady value.

4.2.1.1 Tolerance

None given.

4.2.2 Frequency of Calibration

None given.

4.2.3 Other Calibration Information

None given.

5. Data Acquisition Methods

The signals of the instruments were collected at 20 Hz through a Labmaster board (Scientific Solutions) (analog to digital (A/D) converter) and preprocessed in real time on a microcomputer. The vertical wind speed was high-pass filtered at 0.001 Hz by a digital filter. Sums, sums of square, and sum of cross-product were accumulated over 15 seconds and saved without being converted into the proper units, so that they could be processed again if the calibration factor needed to be changed. Non-linearized signals, like those of the LI-COR 6262, were linearized in real time before being summed.

The tower had the capability to rotate to be aligned in the mean horizontal wind direction. The data acquisition and control system was able to control a fast-response valve to perform conditional sampling based on the vertical wind velocity signal. Nonmethane hydrocarbon was collected in canisters for several periods following REA (Businger and Oncley, 1990; Pattey et al., 1993).

Subcanopy signals were collected via a CR-21X (Campbell Scientific) data logger.

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-OBS site. North American Datum of 1983 (NAD83) coordinates for the site are latitude 53.98717° N, longitude 105.11779° W, and elevation of 628.94 m.

7.1.2 Spatial Coverage Map
Not applicable.

7.1.3 Spatial Resolution
The fluxes measured at 12 m above the displacement height integrate surface contribution, which can be described by footprint functions. The surface contributing to the flux mainly depends on the horizontal wind velocity, the wind direction, surface roughness, the atmospheric stability, and the height of measurements. The spatial coverage can be evaluated by using footprint algorithms (Schuepp et al., 1990; Horst and Weil, 1992). Flux measurements, for which the wind was blowing over a sector including the hut, the ecology tower, and/or the access path, were discarded.

7.1.4 Projection
Not applicable.

7.1.5 Grid Description
Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
Surface flux data were collected during IFC-1 (24-May to 08-Jun), IFC-2 (19-Jul to 01-Aug), and IFC-3 (05- to 19-Sep), 1994.

7.2.2 Temporal Coverage Map
Not available.

7.2.3 Temporal Resolution
The reported data values are 30-minute averages with the reported time corresponding to the start of the sampling period.

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
CO2_FLUX_ABV_CNPY
CO2_CONC_ABV_CNPY
MEAN_WIND_SPEED_ABV_CNPY
SDEV_WIND_SPEED_ABV_CNPY
MEAN_WIND_DIR_ABV_CNPY
SDEV_WIND_DIR_ABV_CNPY
FRICTION_VEL_ABV_CNPY
MEAN_AIR_TEMP_ABV_CNPY
SDEV_AIR_TEMP_ABV_CNPY
DOWN_SOLAR_RAD_ABV_CNPY
MEAN_VAPOR_PRESS_ABV_CNPY
SDEV_VAPOR_PRESS_ABV_CNPY
MEAN_SPECIFIC_HUM_ABV_CNPY
SDEV_SPECIFIC_HUM_ABV_CNPY
TF07_MOMENTUM_FLUX_ABV_CNPY
MEAN_U_WIND_SPEED
MEAN_V_WIND_SPEED
SDEV_U_WIND_SPEED
SDEV_V_WIND_SPEED
SDEV_W_WIND_SPEED
H2O_FLUX_ABV_CNPY
CH4_FLUX_ABV_CNPY
CH4_CONC_ABV_CNPY
N2O_FLUX_ABV_CNPY
N2O_CONC_ABV_CNPY
CRTFCN_CODE
REVISION_DATE

7.3.2 Variable Description/Definition

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

Column Name	Description
SITE_NAME	The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, TRN, and TTT identifies the cover type for the site, 999 if unknown, and CCCCC is the identifier for site, exactly what it means will vary with site type.
SUB_SITE	The identifier assigned to the sub-site by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the sub-site instrument,

	e.g. HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
TIME_OBS	The Greenwich Mean Time (GMT) of the start of the data collection.
SENSIBLE_HEAT_FLUX_ABV_CNPY	The sensible heat flux measured above the canopy.
LATENT_HEAT_FLUX_ABV_CNPY	The latent heat flux 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.
MEAN_WIND_SPEED_ABV_CNPY	The mean wind speed measured above the canopy over a 30 minute period.
SDEV_WIND_SPEED_ABV_CNPY	The standard deviation of the wind speed measured above the canopy over a 30 minute period.
MEAN_WIND_DIR_ABV_CNPY	The mean wind direction measured above the canopy over a 30 minute period.
SDEV_WIND_DIR_ABV_CNPY	The standard deviation of the wind direction measured above the canopy over a 30 minute period.
FRICTION_VEL_ABV_CNPY	The friction velocity above the canopy.
MEAN_AIR_TEMP_ABV_CNPY	The mean air temperature measured above the canopy over a 30 minute period.
SDEV_AIR_TEMP_ABV_CNPY	The standard deviation of the air temperature measured above the canopy over a 30 minute period.
DOWN_SOLAR_RAD_ABV_CNPY	The downward (incoming) solar radiation measured above the canopy.
MEAN_VAPOR_PRESS_ABV_CNPY	The mean vapor pressure measured above the canopy over a 30 minute period.
SDEV_VAPOR_PRESS_ABV_CNPY	The standard deviation of the vapor pressure measured above the canopy over a 30 minute period.
MEAN_SPECIFIC_HUM_ABV_CNPY	The 30 minute mean specific humidity measured above the canopy.
SDEV_SPECIFIC_HUM_ABV_CNPY	The 30 minute standard deviation of specific humidity measured above the canopy.
TF07_MOMENTUM_FLUX_ABV_CNPY	The momentum flux measured above the canopy.
MEAN_U_WIND_SPEED	Mean of a 30 minute period of the streamwise wind speed.
MEAN_V_WIND_SPEED	Mean of a 30 minute period of the lateral wind speed, perpendicular to the U wind vector.
SDEV_U_WIND_SPEED	Standard deviation of the streamwise wind speed.
SDEV_V_WIND_SPEED	Standard deviation of the lateral wind speed.
SDEV_W_WIND_SPEED	Standard deviation of the vertical wind speed.
H2O_FLUX_ABV_CNPY	The water vapor flux measured above the canopy.
CH4_FLUX_ABV_CNPY	The methane flux measured above the canopy.
CH4_CONC_ABV_CNPY	The methane concentration measured above the canopy.
N2O_FLUX_ABV_CNPY	The nitrous oxide flux measured above the canopy.
N2O_CONC_ABV_CNPY	The nitrous oxide concentration measured above the canopy.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

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

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
SENSIBLE_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
LATENT_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
CO2_FLUX_ABV_CNPY	[micromoles][meter^-2][second^-1]
CO2_CONC_ABV_CNPY	[parts per million]
MEAN_WIND_SPEED_ABV_CNPY	[meters][second^-1]
SDEV_WIND_SPEED_ABV_CNPY	[meters][second^-1]
MEAN_WIND_DIR_ABV_CNPY	[degrees from north]
SDEV_WIND_DIR_ABV_CNPY	[degrees from north]
FRICTION_VEL_ABV_CNPY	[meters][seconds^-1]
MEAN_AIR_TEMP_ABV_CNPY	[degrees Celsius]
SDEV_AIR_TEMP_ABV_CNPY	[degrees Celsius]
DOWN_SOLAR_RAD_ABV_CNPY	[Watts][meter^-2]
MEAN_VAPOR_PRESS_ABV_CNPY	[kiloPascals]
SDEV_VAPOR_PRESS_ABV_CNPY	[kiloPascals]
MEAN_SPECIFIC_HUM_ABV_CNPY	[grams][kilogram^-1]
SDEV_SPECIFIC_HUM_ABV_CNPY	[grams][kilogram^-1]
TF07_MOMENTUM_FLUX_ABV_CNPY	[newton][meter^-2]
MEAN_U_WIND_SPEED	[meters][second^-1]
MEAN_V_WIND_SPEED	[meters][second^-1]
SDEV_U_WIND_SPEED	[meters][second^-1]
SDEV_V_WIND_SPEED	[meters][second^-1]
SDEV_W_WIND_SPEED	[meters][second^-1]
H2O_FLUX_ABV_CNPY	[millimoles][meter^-2][second^-1]
CH4_FLUX_ABV_CNPY	[micromoles][meter^-2][second^-1]
CH4_CONC_ABV_CNPY	[parts per million]
N2O_FLUX_ABV_CNPY	[nanomoles][meter^-2][second^-1]
N2O_CONC_ABV_CNPY	[parts per million]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The sources of the parameter values contained in the data files on the CD-ROM are:

Column Name	Data Source
SITE_NAME	[Assigned by BORIS.]
SUB_SITE	[Assigned by BORIS.]
DATE_OBS	[Supplied by Investigator.]
TIME_OBS	[Supplied by Investigator.]
SENSIBLE_HEAT_FLUX_ABV_CNPY	[sonic anemometer]
LATENT_HEAT_FLUX_ABV_CNPY	[Infrared Gas Analyzer]
CO2_FLUX_ABV_CNPY	[Infrared Gas Analyzer]
CO2_CONC_ABV_CNPY	[Infrared Gas Analyzer]
MEAN_WIND_SPEED_ABV_CNPY	[sonic anemometer]
SDEV_WIND_SPEED_ABV_CNPY	[sonic anemometer]

MEAN_WIND_DIR_ABV_CNPY	[sonic anemometer]
SDEV_WIND_DIR_ABV_CNPY	[sonic anemometer]
FRICTION_VEL_ABV_CNPY	[sonic anemometer]
MEAN_AIR_TEMP_ABV_CNPY	[thermocouple]
SDEV_AIR_TEMP_ABV_CNPY	[thermocouple]
DOWN_SOLAR_RAD_ABV_CNPY	[Pyranometer]
MEAN_VAPOR_PRESS_ABV_CNPY	[psychrometer]
SDEV_VAPOR_PRESS_ABV_CNPY	[psychrometer]
MEAN_SPECIFIC_HUM_ABV_CNPY	[psychrometer]
SDEV_SPECIFIC_HUM_ABV_CNPY	[psychrometer]
TF07_MOMENTUM_FLUX_ABV_CNPY	[sonic anemometer]
MEAN_U_WIND_SPEED	[sonic anemometer]
MEAN_V_WIND_SPEED	[sonic anemometer]
SDEV_U_WIND_SPEED	[sonic anemometer]
SDEV_V_WIND_SPEED	[sonic anemometer]
SDEV_W_WIND_SPEED	[sonic anemometer]
H2O_FLUX_ABV_CNPY	[Infrared Gas Analyzer]
CH4_FLUX_ABV_CNPY	[tunable-diode laser]
CH4_CONC_ABV_CNPY	[tunable-diode laser]
N2O_FLUX_ABV_CNPY	[tunable-diode laser]
N2O_CONC_ABV_CNPY	[tunable-diode laser]
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 inthe 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-OBS-FLXTR	SSA-OBS-FLXTR	None	None	None	None
SUB_SITE	9TF07-FLX01	9TF07-FLX01	None	None	None	None
DATE_OBS	24-MAY-94	18-SEP-94	None	None	None	None
TIME_OBS	0	2355	None	None	None	None
SENSIBLE_HEAT_FLUX_ABV_CNPY	-120.1	554.9	-999	None	None	None
LATENT_HEAT_FLUX_ABV_CNPY	-53.1	323.62	-999	None	None	None
CO2_FLUX_ABV_CNPY	-14.069	15.444	-999	None	None	None
CO2_CONC_ABV_CNPY	341.07	411.08	-999	None	None	None
MEAN_WIND_SPEED_ABV_CNPY	.056	7.853	-999	None	None	None
SDEV_WIND_SPEED_ABV_CNPY	.081	2.485	-999	None	None	None
MEAN_WIND_DIR_ABV_CNPY	0	370.8	-999	None	None	None
SDEV_WIND_DIR_ABV_CNPY	.05	181.154	-999	None	None	None
FRICTION_VEL_ABV_CNPY	0	1.155	-999	None	None	None
MEAN_AIR_TEMP_ABV_CNPY	3.85	26.59	-999	None	None	None
SDEV_AIR_TEMP_ABV_	.05	1.51	-999	None	None	None

CNPY						
DOWN_SOLAR_RAD_ABV_ CNPY	-66.36	852.52	-999	None	None	None
MEAN_VAPOR_PRESS_ABV _CNPY	.501	1.882	-999	None	None	None
SDEV_VAPOR_PRESS_ABV _CNPY	.001	.114	-999	None	None	None
MEAN_SPECIFIC_HUM_ ABV_CNPY	3.217	12.407	-999	None	None	None
SDEV_SPECIFIC_HUM_ ABV_CNPY	.006	.746	-999	None	None	None
TF07_MOMENTUM_FLUX_ ABV_CNPY	-1.531	.073	-999	None	None	None
MEAN_U_WIND_SPEED	-6.248	6.388	-999	None	None	None
MEAN_V_WIND_SPEED	-4.339	4.855	-999	None	None	None
SDEV_U_WIND_SPEED	.063	3.628	-999	None	None	None
SDEV_V_WIND_SPEED	.083	2.525	-999	None	None	None
SDEV_W_WIND_SPEED	.009	1.574	-999	None	None	None
H2O_FLUX_ABV_CNPY	-1.192	7.348	-999	None	None	None
CH4_FLUX_ABV_CNPY	-22724	99192	-999	None	None	None
CH4_CONC_ABV_CNPY	0	3.34	-999	None	None	None
N2O_FLUX_ABV_CNPY	-5.047	2.386	-999	None	None	None
N2O_CONC_ABV_CNPY	.258	.322	-999	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	23-MAR-99	23-MAR-99	None	None	None	None

Minimum Data Value -- The minimum value found in the column.
Maximum Data Value -- The maximum value found in the column.
Missng Data Value -- The value that indicates missing data. This is used to indicate that an attempt was made to determine the parameter value, but the attempt was unsuccessful.
Unrel Data Value -- The value that indicates unreliable data. This is used to indicate an attempt was made to determine the parameter value, but the value was deemed to be unreliable by the analysis personnel.
Below Detect Limit -- The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined that the parameter value was below the detection limit of the instrumentation.
Data Not Cllctd -- This value indicates that no attempt was made to determine the parameter value. This usually indicates that BORIS combined several similar but not identical data sets into the same data base table but this particular science team did not measure that parameter.

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

7.4 Sample Data Record
The following are wrapped versions of data records from a sample data file on the CD-ROM.

```
SITE_NAME,SUB_SITE,DATE_OBS,TIME_OBS,SENSIBLE_HEAT_FLUX_ABV_CNPY,
LATENT_HEAT_FLUX_ABV_CNPY,CO2_FLUX_ABV_CNPY,CO2_CONC_ABV_CNPY,
MEAN_WIND_SPEED_ABV_CNPY,SDEV_WIND_SPEED_ABV_CNPY,MEAN_WIND_DIR_ABV_CNPY,
SDEV_WIND_DIR_ABV_CNPY,FRICTION_VEL_ABV_CNPY,MEAN_AIR_TEMP_ABV_CNPY,
SDEV_AIR_TEMP_ABV_CNPY,DOWN_SOLAR_RAD_ABV_CNPY,MEAN_VAPOR_PRESS_ABV_CNPY,
SDEV_VAPOR_PRESS_ABV_CNPY,MEAN_SPECIFIC_HUM_ABV_CNPY,SDEV_SPECIFIC_HUM_ABV_CNPY,
TF07_MOMENTUM_FLUX_ABV_CNPY,MEAN_U_WIND_SPEED,MEAN_V_WIND_SPEED,
SDEV_U_WIND_SPEED,SDEV_V_WIND_SPEED,SDEV_W_WIND_SPEED,H2O_FLUX_ABV_CNPY,
CH4_FLUX_ABV_CNPY,CH4_CONC_ABV_CNPY,N2O_FLUX_ABV_CNPY,N2O_CONC_ABV_CNPY,
CRTFCN_CODE,REVISION_DATE
'SSA-OBS-FLXTR','9TF07-FLX01',01-JUN-94,0,129.8,84.24,-1.976,368.18,1.878,1..008,
201.8,173.501,.36,18.8,.5,432.44,.561,.019,3.648,.125,-.148,.495,1.547,.952,
1.059,.585,1.735,-999.0,-999.0,-999.0,-999.0,'CPI',23-MAR-99
'SSA-OBS-FLXTR','9TF07-FLX01',01-JUN-94,30,23.14,43.97,-1.55,368.05,1.82,.919,
263.8,163.469,.273,18.2,.34,221.26,.575,.022,3.735,.142,-.085,.888,1.514,.708,
.836,.376,.956,-999.0,-999.0,-999.0,-999.0,'CPI',23-MAR-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
See Section 9.1.1.

9.1.1 Derivation Techniques and Algorithms
Momentum flux (FU; N/m^2):

$$FU = rhoa \langle W'U1' \rangle$$

where:
- W: vertical wind velocity (m/s)
- U1: horizontal wind speed (m/s1)
- $\langle\ \rangle$: average over the averaging period
- ': fluctuation
- rhoa: air density (g/m^3)

Sensible heat flux (FT; W/m^2)

$$FT = rhoa\ Cp\ \langle W'T' \rangle$$

where: Cp: air specific heat at constant pressure
T: air temperature (C)
FT is corrected for humidity and velocity fluctuations (Schotanus et al., 1983)

Latent heat flux (FQ; W/m^2):

$$FQ = L\ rhoa\ MV/MA\ \langle W'NQ' \rangle\ 10^{-3}$$

where: L: coefficient of vaporization (J/g/K)
MV: molecular mass of water vapor (18 g/mol^2)
MA: molecular mass of dry air (29 g/mol)
NQ: molar fraction (mmol H_2O/mol^2 dry air)

Flux of trace gases (FS; g/m^2/s):

$$FS = rhoa\ MS/MA\ \langle W'NS' \rangle + rhoS\ DF$$

where: NS: molar fraction of the species (mol S/mol^2 dry air)
MS: molecular mass of the species (g/mol)
rhoS: density of the species (g/m^3)
DF= density fluctuation correction (Webb et al., 1980)
e species (g/mol)
rhoS: density of the species (g/m^3)
DF= density fluctuation correction (Webb et al., 1980)

Expected sensitivity of trace gases to density fluctuation correction can be found in Pattey et al (1992).
For CO_2 flux measured by the LI-COR 6262, only density fluctuations due to water vapor fluctuations are involved in the correction.

9.2 Data Processing Sequence

The following steps were used to process the data:

- Collection of 15-s blocks.
- Sum over the averaging period.
- Scaling and conversion of binary data to channel units.
- Mean, standard deviation, and flux calculation.

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

None.

9.3.2 Calculated Variables

Sensible heat flux, latent heat flux, momentum flux, trace gas fluxes of CO_2, CH_4, and N_2O.

9.4 Graphs and Plots

None.

10. Errors

10.1 Sources of Error

None given.

10.2 Quality Assessment

The data were not verified against wind direction and rejection sector.

10.2.1 Data Validation by Source

None given.

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

Data were collected only during the IFCs in 1994.

11.2 Known Problems with the Data

Missing data with TDL-TGAS are associated with vibration problems, analysis of REA samples, and, for IFC-1, pump troubleshooting.

11.3 Usage Guidance

None given.

11.4 Other Relevant Information

None given.

12. Application of the Data Set

These data are useful for the study of water, energy, carbon, and nitrogen exchange in a mature black spruce forest.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description

None given.

14.2 Software Access

None.

15. Data Access

The SSA-OBS tower flux and meteorological 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 given.

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
AG      - Aerodynamic Gradient
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
EC      - Eddy Covariance
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
IFC     - Intensive Field Campaign
IRGA    - Infrared Gas Analyzer
NAD83   - North American Datum of 1983
NASA    - National Aeronautics and Space Administration
NSA     - Northern Study Area
OBS     - Old Black Spruce
ORNL    - Oak Ridge National Laboratory
PANP    - Prince Albert National Park
PAR     - Photosynthetically Active Radiation
PC      - Personal Computer
PPFD    - Photosynthetic Photon Flux Density
REA     - Relaxed Eddy Accumulation
REBS    - Radiation Energy Balance Systems
SSA     - Southern Study Area
TDL     - Tunable-Diode Laser
TF      - Tower Flux
TGA     - Trace Gas Analyzer
TGB     - Trace Gas Biogeochemistry
TGAS    - Trace Gas Analyzer System
URL     - Uniform Resource Locator
WAB     - Wind Aligned Blob
WMO     - World Meteorological Organization
```

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13. ABSTRACT *(Maximum 200 words)*

The BOREAS TF-7 team collected meteorological data as well as energy, carbon dioxide, water vapor, methane, and nitrous oxide flux data at the BOREAS SSA-OBS site. The data were collected from 24-May to 19-Sep-1994. The data are available in tabular ASCII files.

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