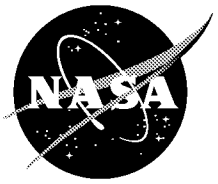
NASA/TM—2000–209891, Vol. 227



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

Forrest G. Hall and Sara K. Conrad, Editors

Volume 227

BOREAS TGB-4 NSA-BVP Tower Flux and Meteorological Data

Nigel T. Roulet
McGill University, Montreal, Quebec

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

November 2000

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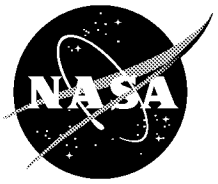

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BOREAS TGB-4 NSA-BVP Tower Flux and Meteorological Data

Nigel T. Roulet

Summary

The BOREAS TGB-4 team measured the exchange of heat, water, and CO_2 between a boreal forest beaver pond and the atmosphere in the NSA for the ice-free period of BOREAS. The data cover the period of 28-May to 18-Sep-1994. The data are available in tabular ASCII files.

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1) Data Set Overview
2) Investigator(s)
3) Theory of Measurements
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14) Software
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1. Data Set Overview

1.1 Data Set Identification

BOREAS TGB-04 NSA-BVP Tower Flux and Meteorological Data

1.2 Data Set Introduction

This data set includes heat, CO_2, and water vapor fluxes measured from the BOReal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA)-Beaver Pond (BVP) tower. Anemometer, temperature (wet and dry bulb), and CO_2 profile measurements were collected from a tower located in the middle of a beaver pond. These data along with radiometric measurements were used to calculate the surface turbulent fluxes using the profile and energy balance technique. Measurements of the water level, flow rates, and light penetration of the beaver pond were also collected.

1.3 Objective/Purpose

The objective of this study was to quantify the exchange of heat, water, and CO_2 between boreal forest beaver ponds and the atmosphere for the ice-free period of BOREAS. The fluxes of heat, water, and CO_2 from one beaver pond were measured continuously using the energy balance Bowen ratio approach. The diffuse and bubble flux CH_4 were measured several times a week using chambers. The chamber approach was used to sample CO_2 and CH_4 flux from four to five additional beaver ponds, once every 2 weeks, and regional surveys of the surface concentrations of CO_2, CH_4, and dissolved organic carbon (DOC) were carried out on accessible beaver ponds.

1.4 Summary of Parameters

Variables measured include latent heat flux, sensible heat flux, soil heat flux, CO_2 flux, net radiation, incident and reflected Photosynthetically Active Radiation (PAR), underwater PAR, incident and reflected solar radiation, wind speed and direction, precipitation amount, air temperature, vapor pressure, air pressure, flow rate of water out of the pond, and water table height.

1.5 Discussion

In BOREAS, each surface flux station was located in a unique boreal forest ecosystem component in northern and southern study areas, in an attempt to characterize the boreal forest at both the northern and southern extremes of its extent. In this study, the surface flux station was deployed in a beaver pond to make measurements of the fluxes of CO_2, CH_4, and the energy budget components. These fluxes were considered important in characterizing wetlands of the boreal forest. The surface fluxes were measured using the profile and energy balance technique. Supporting meteorological measurements were also made at this site.

1.6 Related Data Sets

BOREAS TGB-01 CH4 Concentration and Flux Data from NSA Tower Sites
BOREAS TF-10 NSA-Fen Tower Flux and Meteorological Data
BOREAS TF-11 SSA-Fen Tower Flux and Meteorological Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. N.T. Roulet
Department of Geography
McGill University

2.2 Title of Investigation

The Fluxes of Energy and Trace Gases from Beaver Ponds and Dry Upland Forest Floor in the NSA

2.3 Contact Information

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3. Theory of Measurements

A four-level profile measurement system of temperature, wind speed, humidity, and CO_2 were used to calculate the flux of sensible heat, momentum, latent heat, and CO_2, respectively, from a tower located in the middle of a beaver pond. According to well-accepted footprint theory, the tower was sufficiently low to the ground to obtain flux measurements representative of the pond and not the surrounding forested area. Differential measurements between levels were then used to calculate the actual fluxes based upon the well-proven profile technique.

4. Equipment

4.1 Sensor/Instrument Description

Instrumentation at this site was fairly elaborate. The basis of the system was the Campbell Scientific CR7 data logger, which controlled operation and saved incoming data for later analysis. Also included was a LI-COR model 6252 CO_2 analyzer capable of measuring CO_2 concentrations at a fast sampling rate.

Measurements were collected from a short tower using a profile system at 25 cm, 50 cm, 100 cm, and 150 cm above the pond surface. Gas sampling locations were switched automatically by the data logger, allowing sufficient time to purge the sampling lines of the previous level's air before a measurement was taken.

Due to the fluctuating nature of the pond surface height, continuous measurements were made of its movement (by potentiometer). The surface heights were then used to correct the actual height of the instruments above the water surface as this greatly affects the calculated fluxes.

4.1.1 Collection Environment

Measurements were collected from the end of May through mid-September of 1994. Over that time period, temperature conditions ranged from slightly below freezing to about 28 °C.

4.1.2 Source/Platform

A ground-based platform was situated on a stable dock-like structure in the center of the pond. It was accessible by a floating boardwalk. The tower was mounted on this dock, and the profile instruments were placed at the appropriate levels and wired back to a low-profile instrument box also on this dock. Within this box were the data logger, CO_2 analyzer, gas sampler switching system (from one level to the next), and power supply panel and converter from 120V AC to 12V DC.

4.1.3 Source/Platform Mission Objectives

The mission objective was to collect continuous energy balance and CO_2 fluxes from an active beaver pond surface.

4.1.4 Key Variables

Profile measurements, all at 0.25, 0.5, 1.0, and 1.5 m:

- Temperature profile (using thermocouples)
- Moisture profile (using thermocouples and wet/dry bulb technique)
- Wind speed profile
- CO_2 concentration
- CH_4 concentration

Nonprofile measurements:

- Water table measurements referenced to lowest instrument profile level (0.25 m)
- Incoming solar radiation (up-facing pyranometer)
- Outgoing solar radiation (down-facing pyranometer)
- Net radiation (all-wave radiometer)
- Water temperature profile (1 cm, 5 cm, 10 cm, 20 cm) (using thermocouples)
- Atmospheric pressure at surface
- Incoming PAR
- Outgoing PAR
- Wind direction
- Precipitation
- Underwater PAR

4.1.5 Principles of Operation

The calculation of fluxes required a calculation based upon measured momentum flux. Wind speed profiles determine the momentum flux toward the surface and the associated transfer coefficient Km is calculated and corrected for stability by temperature profile measurements. Using similarity theory, the same transfer coefficient is applied to the fluxes of sensible and latent heat, and CO_2 using the formula of the form:

$$\text{Flux} = K \times dA/dz$$

where K is the eddy diffusivity or transfer coefficient, and the second term is the gradient of the entity concerned. A good review of the procedures used is found within Oke (1987), Appendix A2, Section 2b. Given the calculations of sensible and latent heat and measured net, incoming, and outgoing radiation, this allows closure of the energy and surface balance equations by attributing the difference to the ground heat flux (Qg).

4.1.6 Sensor/Instrument Measurement Geometry

All profile measurements collected data at heights of 0.25, 0.5, 1.0, and 1.5 m above the water surface when established, with water surface fluctuation accounted for during operation.

Wind direction, incoming and outgoing radiation sensors, and net radiation were measured 2 m above established water surface.

Atmospheric pressure and precipitation were measured on the tower platform.

4.1.7 Manufacturer of Sensor/Instrument

Thermocouples (for both dry and wet bulb):
Type T
Supplier: Electrosonic, Inc.
1100 Gordon Baker Road
Willowdale, Ontario, Canada M2H 3B3

Data Loggers and Multiplexes:
Campbell Scientific Canada Corp.
11564-149th Street
Edmonton, AB, Canada T5M 1W7
(403) 454-2505
(403) 454-2655 (fax)

Water Table Measurement
Twenty Turn Bournes Precision Potentiometers
Manufactured by: Electrosonic, Inc.
1100 Gordon Baker Road
Willowdale, Ontario, Canada M2H 3B3

Anemometry: R.M. Young Company (via Campbell Scientific)
Wind direction: R.M. Young Company (via Campbell Scientific)

CO_2 concentration:
LI-COR Model 6252 Gas Analyzer
LI-COR, Inc.
P.O. Box 4425
Lincoln, NE 68504
(402) 467-3576

Pyranometers: Kipp and Zonen, Model CM11

Net Radiometer: Middleton

Atmospheric pressure: Met-One Model 090B-4 (via Campbell Scientific)

PAR Sensors: L-ICOR Model 'Quantum'
LI-COR, Inc.
P.O. Box 4425
Lincoln, NE 68504
(402) 467-3576

Underwater PAR: LI-COR Model 'Underwater'
LI-COR, Inc.
P.O. Box 4425
Lincoln, NE 68504
(402) 467-3576

Precipitation: Sierra/MISCO, Inc., Tipping bucket model 2501
Sierra/MISCO, Inc.
1825 Eastshore Highway
Berkeley, CA 94710

4.2 Calibration

- Thermocouples: all calibrated before deployment to ensure there were no offsets between the psychrometers. Also, at the end of the field season, all psychrometers were run horizontally to determine if any offsets had developed over the summer.
- Anemometry: calibrated prior to deployment.
- Radiometric sensors (net radiation, PAR, solar): calibrated prior to deployment.
- CO_2 gas analyzer: calibrated prior to setup, midsummer, and end of season. Note that for these profile measurements, absolute CO_2 concentration need not be exact, since it is the difference between levels that is important to calculate the flux.
- Water level: a potentiometer and machined aluminum wheel calibrated from previous experiments were used. Weekly manual measurements of water table depth were taken to ensure proper calibration of the electronic measurement which is required to account for the changing heights of the instruments above the water surface.

4.2.1 Specifications

- Thermocouples: type T thermocouple rated at ±0.001 °C maximum error
- Anemometry: rated at 0.1 m/s with a stall speed of 0.1 m/s
- Wind direction: ± 2°
- CO_2 concentration: ±0.1 ppm (0,02 ppm with 15-second averaging time used)
- Radiometry: approximately ±1.0 W/m^2
- Water levels: maximum error of ±1 mm
- Precipitation: ±1 mm
- Atmospheric pressure: ±0.01 kPa

4.2.1.1 Tolerance

- Thermocouples: range allowable: ±62.5 °C of data logger temperature
- Anemometry: range: within observable limits
- CO_2 concentration: 0 to 1000 ppm
- Radiometry: within observable limits
- Water levels range allowable: large; depends upon length of beaded cable
- Atmospheric pressure: approximately 90-106 kPa

4.2.2 Frequency of Calibration

All instruments were calibrated once, before field deployment, except the gas analyzer, which was also calibrated midsummer and checked again at the end of the field season.

4.2.3 Other Calibration Information

No corrections were required according to the calibration methods described above.

5. Data Acquisition Methods

Anemometer, temperature (wet and dry bulb), and CO_2 profile measurements on the tower, along with radiometric measurements, were used to calculate the surface turbulent fluxes using the profile and energy balance technique.

Each of these parameters was measured every 10 seconds and averaged, and then saved on the data logger every 30 minutes. These data were later transferred to computer, where the energy and CO_2 flux values were calculated using the standard flux-profile technique.

Radiometric, temperature, CO_2, and pressure readings were made by differential voltage measurements, which were multiplied by a calibration coefficient at the data logger and saved for later download. A CO_2 concentration at each level was determined once very 90 seconds.

The data logger controlled switching of the gas sampling ports (at each level) automatically by solenoids, and saved the associated 30-minute average reading for later download.

For water level readings, a potentiometer varied the voltage measured by the data logger as the float (or bog shoe) on the beaded cable rose and lowered in response to water table changes. The data logger measured this changing voltage, which was easily converted into the height change since the potentiometers were calibrated to 1 mV of change being equal to 1 mm of vertical water change. This reading was saved and used for the recalculation of instrument heights every 30 minutes.

6. Observations

6.1 Data Notes

There are several periods of missing data within this set, due mainly to generator failure. In most cases, these periods are less than 24 hours, since daily visits to check instrumentation were made throughout the field campaign.

6.2 Field Notes

None.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

All data were collected at the BOREAS NSA BVP site. North American Datum of 1983 (NAD83) coordinates for the site are latitude 55.84225° N, longitude 98.02747° W, and elevation of 186.74 m.

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

The tower was set up in the center of a beaver pond complex considered to be representative of this environment according to standard footprint theory. The tower was placed to give a 150-m fetch in all directions except for 310° to 100°. In this section, the fetch was less than 100 m.

7.1.4 Projection

None.

7.1.5 Grid Description

None.

7.2 Temporal Characteristics

The data were collected continuously every 10 seconds for all variables except CO_2 concentration, which was collected every 30 seconds. All readings were then averaged over 30-minute intervals (180 and 60 measurements, respectively, for average calculation).

7.2.1 Temporal Coverage

The data were collected during the summer of 1994 between the months of May and September.

7.2.2 Temporal Coverage Map

None.

7.2.3 Temporal Resolution

Resolution is 30 minutes. These represent average values of the previous 30 minutes.

7.3 Data Characteristics

7.3.1 Parameter/Variable

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

Column Name
SITE_NAME
SUB_SITE
DATE_OBS
TIME_OBS
SENSIBLE_HEAT_FLUX_ABV_CNPY
LATENT_HEAT_FLUX_ABV_CNPY
NET_RAD_ABV_CNPY
SOIL_HEAT_FLUX
CO2_FLUX_ABV_CNPY
DOWN_PAR_ABV_CNPY
UP_PAR_ABV_CNPY
DOWN_PAR_UNDER_WATER
WIND_DIR_200CM
WIND_SPEED_100CM
AIR_TEMP_100CM
VAPOR_PRESS_ABV_CNPY
RAINFALL
DOWN_SOLAR_RAD_ABV_CNPY
UP_SOLAR_RAD_ABV_CNPY
SURF_PRESS
WATER_TABLE_HGT
WATER_OUTFLOW_WEST
WATER_OUTFLOW_EAST
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) when the data were collected.

SENSIBLE_HEAT_FLUX_ABV_CNPY	The sensible heat flux measured above the canopy.
LATENT_HEAT_FLUX_ABV_CNPY	The latent heat flux measured above the canopy.
NET_RAD_ABV_CNPY	The net radiation measured above the canopy.
SOIL_HEAT_FLUX	The surface soil heat flux.
CO2_FLUX_ABV_CNPY	The carbon dioxide flux measured above the canopy.
DOWN_PAR_ABV_CNPY	The incoming photosynthetically active radiation measured above the canopy.
UP_PAR_ABV_CNPY	The reflected (outgoing) photosynthetically active radiation measured above the canopy.
DOWN_PAR_UNDER_WATER	The incoming photosynthetically active radiation measured under water.
WIND_DIR_200CM	The wind direction measured at 2 meters above the reference surface.
WIND_SPEED_100CM	The wind speed measured at 1 meter above the reference surface.
AIR_TEMP_100CM	The air temperature measured at 1 meter above the reference surface.
VAPOR_PRESS_ABV_CNPY	The vapor pressure measured above the canopy.
RAINFALL	The amount of rainfall measured above the canopy in the 30 minute period following the given time.
DOWN_SOLAR_RAD_ABV_CNPY	The downward (incoming) solar radiation measured above the canopy.
UP_SOLAR_RAD_ABV_CNPY	The reflected (outgoing) solar radiation measured above the canopy.
SURF_PRESS	The atmospheric pressure measured at the station.
WATER_TABLE_HGT	Water table height above a reference surface.
WATER_OUTFLOW_WEST	The volume of water leaving the pond from the western drainage.
WATER_OUTFLOW_EAST	The volume of water leaving the pond from the eastern drainage.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

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

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
SENSIBLE_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
LATENT_HEAT_FLUX_ABV_CNPY	[Watts][meter^-2]
NET_RAD_ABV_CNPY	[Watts][meter^-2]
SOIL_HEAT_FLUX	[Watts][meter^-2]
CO2_FLUX_ABV_CNPY	[micromoles][meter^-2][second^-1]
DOWN_PAR_ABV_CNPY	[watts][meter^-2]
UP_PAR_ABV_CNPY	[watts][meter^-2]

DOWN_PAR_UNDER_WATER	[watts][meter^-2]
WIND_DIR_200CM	[degrees from North]
WIND_SPEED_100CM	[meters][second^-1]
AIR_TEMP_100CM	[degrees Celsius]
VAPOR_PRESS_ABV_CNPY	[kiloPascals]
RAINFALL	[millimeters]
DOWN_SOLAR_RAD_ABV_CNPY	[Watts][meter^-2]
UP_SOLAR_RAD_ABV_CNPY	[Watts][meter^-2]
SURF_PRESS	[kiloPascals]
WATER_TABLE_HGT	[millimeters]
WATER_OUTFLOW_WEST	[meters^3][second^-1]
WATER_OUTFLOW_EAST	[meters^3][second^-1]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

The sources of the parameter values contained in the data files onthe 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	[Supplied by Investigator.]
LATENT_HEAT_FLUX_ABV_CNPY	[Supplied by Investigator.]
NET_RAD_ABV_CNPY	[Net radiometer]
SOIL_HEAT_FLUX	[Supplied by Investigator.]
CO2_FLUX_ABV_CNPY	[Infrared Gas Analyzer]
DOWN_PAR_ABV_CNPY	[quantum sensor]
UP_PAR_ABV_CNPY	[quantum sensor]
DOWN_PAR_UNDER_WATER	[quantum sensor]
WIND_DIR_200CM	[windvane]
WIND_SPEED_100CM	[anemometer]
AIR_TEMP_100CM	[Thermocouple]
VAPOR_PRESS_ABV_CNPY	[wet/dry thermocouples]
RAINFALL	[tipping bucket rain gauge]
DOWN_SOLAR_RAD_ABV_CNPY	[Pyranometer]
UP_SOLAR_RAD_ABV_CNPY	[Pyranometer]
SURF_PRESS	[barometer]
WATER_TABLE_HGT	[Potentiometer]
WATER_OUTFLOW_WEST	[Supplied by Investigator.]
WATER_OUTFLOW_EAST	[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	NSA-BVP-FLXTR	NSA-BVP-FLXTR	None	None	None	None
SUB_SITE	TGB04-FLX01	TGB04-FLX01	None	None	None	None
DATE_OBS	28-MAY-94	17-SEP-94	None	None	None	None
TIME_OBS	0	2330	None	None	None	None
SENSIBLE_HEAT_FLUX_ABV_CNPY	-643.31	832.66	-999	None	None	None
LATENT_HEAT_FLUX_ABV_CNPY	-868.65	824.41	-999	None	None	None
NET_RAD_ABV_CNPY	-137.6	769	-999	None	None	None
SOIL_HEAT_FLUX	-498.83	1035.11	-999	None	None	None
CO2_FLUX_ABV_CNPY	-25	23.4224	-999	None	None	Blank
DOWN_PAR_ABV_CNPY	0	412.1	-999	None	None	None
UP_PAR_ABV_CNPY	0	26.68	-999	None	None	None
DOWN_PAR_UNDER_WATER	0	71.2	-999	None	None	None
WIND_DIR_200CM	0	359.5	-999	None	None	None
WIND_SPEED_100CM	.2	5.98	-999	None	None	None
AIR_TEMP_100CM	-2.32	28.67	-999	None	None	None
VAPOR_PRESS_ABV_CNPY	.5	3.15	-999	None	None	None
RAINFALL	0	129.84	-999	None	None	Blank
DOWN_SOLAR_RAD_ABV_CNPY	0	959	-999	None	None	None
UP_SOLAR_RAD_ABV_CNPY	0	107.5	-999	None	None	None
SURF_PRESS	97.7	101.7	-999	None	None	None
WATER_TABLE_HGT	-2.495	1.362	-999	None	None	Blank
WATER_OUTFLOW_WEST	0	2932.243	-999	None	None	Blank
WATER_OUTFLOW_EAST	0	.03	-999	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	17-MAR-99	17-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 record from a sample data file on the CD-ROM.

```
SITE_NAME,SUB_SITE,DATE_OBS,TIME_OBS,SENSIBLE_HEAT_FLUX_ABV_CNPY,
LATENT_HEAT_FLUX_ABV_CNPY,NET_RAD_ABV_CNPY,SOIL_HEAT_FLUX,CO2_FLUX_ABV_CNPY,
DOWN_PAR_ABV_CNPY,UP_PAR_ABV_CNPY,DOWN_PAR_UNDER_WATER,WIND_DIR_200CM,
WIND_SPEED_100CM,AIR_TEMP_100CM,VAPOR_PRESS_ABV_CNPY,RAINFALL,
DOWN_SOLAR_RAD_ABV_CNPY,UP_SOLAR_RAD_ABV_CNPY,SURF_PRESS,WATER_TABLE_HGT,
WATER_OUTFLOW_WEST,WATER_OUTFLOW_EAST,CRTFCN_CODE,REVISION_DATE
'NSA-BVP-FLXTR','TGB04-FLX01',28-MAY-94,2200,-6.73,102.54,269.3,173.49,1.8638,
170.1,13.31,23.02,134.3,3.32,24.28,.88,-999.0,359.3,33.13,98.9,1.281,-999.0,
-999.0,'CPI',17-MAR-99
'NSA-BVP-FLXTR','TGB04-FLX01',28-MAY-94,2230,-11.54,177.5,257.2,91.24,3.1192,
162.8,12.81,22.13,152.5,3.7,24.7,.87,-999.0, 347.6,31.97,98.9,1.281,-999.0,
-999.0,'CPI',17-MAR-99
'NSA-BVP-FLXTR','TGB04-FLX01',28-MAY-94,2300,-17.85,260.95,252.1,9.0,2.4295,
157.8,11.83,21.7,141.4,3.92,24.5,.85,-999.0,342.8,29.13,98.8,1.281,-999.0,
-999.0,'CPI',17-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

9.1.1 Derivation Techniques and Algorithms

The calculation of fluxes required later computer calculation based upon measured momentum flux. Wind speed profiles determine the momentum flux toward the surface and the associated transfer coefficient Km is calculated and corrected for stability by temperature profile measurements. Using similarity theory, the same transfer coefficient is applied to the fluxes of sensible and latent heat, and CO_2 using the formula of the form:

Flux = K x dA/dz

where K is the eddy diffusivity or transfer coefficient, and the second term is the gradient of the entity concerned. A good review of the procedures used is found within Oke (1987), Appendix A2, Section 2b. Given the calculations of sensible and latent heat and measured net, incoming, and outgoing radiation, this allows closure of the energy and surface balance equations by attributing the difference to the ground heat flux (Qg).

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

None.

9.3.2 Calculated Variables

The CO_2 flux and the latent, sensible, and soil heat fluxes were calculated.

9.4 Graphs and Plots

None.

10. Errors

10.1 Sources of Error

Instrument error could occur due to wire disconnection or shorting, multiplexer or data logger malfunction, or battery or generator failure. In addition, due to the elaborate nature of calculating fluxes based upon profile measurements, certain theoretical errors can become large in some situations. These situations occur mainly at dusk and overnight when wind speeds become very small and differences in wind speed become negligible over such a short tower. In these cases, the eddy diffusivity can become zero, resulting in a zero flux value. Under these circumstances, our methods would suggest there are no fluxes either up or down, although they must be occurring, but below the sensitivity of ordinary profile system anemometry. In addition, very small gradients of any parameter approaching the limitations of the instrument could also result in an underestimate of the actual existing flux by reducing the gradient to something approaching zero. This may seem important; however, these times occur infrequently, and the fluxes must be quite small. In any case, over a diurnal period the errors associated with the profile technique are not thought to be a significant missing component of the energy or CO_2 balance.

10.2 Quality Assessment

10.2.1 Data Validation by Source

All data were plotted and checked to determine if there were any outlying points that were obviously incorrect. These points were removed and replaced by -999, which was used to indicate missing or bad values within the data set submitted.

10.2.2 Confidence Level/Accuracy Judgment

The confidence level of this data set is high, since the submitted data have been visually checked for inconsistencies. Perhaps the greatest potential error is associated with the ground heat flux (Qg), which is obtained by residual. This same system has been used successfully in previous experiments at the Experimental Lakes Area, in northwest Ontario.

10.2.3 Measurement Error for Parameters

Energy balance terms are thought to be within 10% when calculated, and certainly less than that when measured directly, the error in this case is discussed in Section 5.2.1. As discussed above, ground heat flux error could be larger since it is calculated by residual from all other energy budget terms.

10.2.4 Additional Quality Assessments

Since the calculated surface energy budget and CO_2 flux is based upon the calculation of an accurate momentum flux or eddy diffusivity value (K), a test was initiated toward the end of the campaign to test this calculated variable. In addition to the profile measurements of wind speed, a sonic anemometer was placed on the tower and the momentum coefficient was calculated using this instrument. Over the 4 days of overlapping measurement, differences between systems were not significant, and no corrections due to over- or underestimation were suggested.

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

See Section 10.1.

11.2 Known Problems with the Data

There were no known problems with the submitted data.

11.3 Usage Guidance

None required.

11.4 Other Relevant Information

Beavers were frequently sighted, and seemed completely undisturbed by our tower in the center of their pond. In fact, they seemed quite inquisitive and were often seen passing near the tower platform. There was one bear sighting at the pond edge, even with the nearby noisy generator. Fauna environmental impact was therefore negligible.

12. Application of the Data Set

These data are useful for the study of water, energy, and carbon exchange in a beaver pond.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description

None given.

14.2 Software Access

None given.

15. Data Access

The NSA-BVP 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

Campbell Scientific Corporation CR7 Manual LI-COR 6252 Gas Analyzer Manual

17.2 Journal Articles and Study Reports

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.

Oke, T.R. 1987. Boundary layer climates. Routledge, Second Edition, New York, 435p.

Roulet, N.T., N. Comer, A. Dove, J. Etchevery, C. Robinson, S. Glenn, and P. Crill. (date unknown). Missing carbon sinks, beaver ponds, and the boreal carbon budget. Centre for Climate and Global Change Newsletter, 6(1): 5-8.

Roulet, N.T., P.M. Crill, N.T. Comer, A.E. Dove, and R.A. Boubonniere. 1997. CO_2 and CH_4 flux between a boreal beaver pond and the atmosphere. Journal of Geophysical Research 102(D24): 29,313-29,319.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

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Sellers, P., F. Hall, 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

```
A/D     - Analog to Digital
ASCII   - American Standard Code for Information Interchange
BOREAS  - BOReal Ecosystem-Atmosphere Study
BORIS   - BOREAS Information System
BVP     - Beaver Pond
CD-ROM  - Compact Disk-Read-Only Memory
DAAC    - Distributed Active Archive Center
DOC     - Dissolved Organic Carbon
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
IRGA    - Infrared Gas Analyzer
NAD83   - North American Datum of 1983
NASA    - National Aeronautics and Space Administration
NSA     - Northern Study Area
ORNL    - Oak Ridge National Laboratory
PANP    - Prince Albert National Park
PAR     - Photosynthetically Active Radiation
PC      - Personal Computer
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PPFD     - Photosynthetic Photon Flux Density
REBS     - Radiation Energy Balance Systems
SSA      - Southern Study Area
TF       - Tower Flux
TGB      - Trace Gas Biogeochemistry
URL      - Uniform Resource Locator
WAB      - Wind Aligned Blob
WMO      - World Meteorological Organization
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The BOREAS TGB-4 team measured the exchange of heat, water, and CO_2 between a boreal forest beaver pond and the atmosphere in the NSA for the ice-free period of BOREAS. The data cover the period of 28-May to 18-Sep-1994. The data are available in tabular ASCII files.

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