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

Forrest G. Hall and David E. Knapp, Editors

Volume 215

BOREAS TF-11 SSA-Fen Leaf Gas Exchange Data

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National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

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BOREAS TF-11 SSA-Fen Leaf Gas Exchange Data

Timothy J. Arkebauer

Summary

The BOREAS TF-11 team gathered a variety of data to complement its tower flux measurements collected at the SSA-Fen site. This data set contains single-leaf gas exchange data from the SSA-Fen site during 1994 and 1995. These leaf gas exchange properties were measured for the dominant vascular plants using portable gas exchange systems. The data are stored in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS TF-11 SSA-Fen Leaf Gas Exchange Data

1.2 Data Set Introduction

The BOReal Ecosystem-Atmosphere Study (BOREAS) Tower Flux (TF)-11 team collected single-leaf gas exchange data at the Southern Study Area (SSA)-Fen site in 1994 and 1995. These leaf gas exchange properties were measured for the dominant vascular plants using portable gas exchange systems. The variables that were measured include leaf species, leaf area, boundary layer conductance, leaf temperature, net CO_2 assimilation rate, stomatal conductance, internal CO_2 concentration, photosynthetic photon flux density (PPFD), air temperature, CO_2 concentration, relative humidity, and air vapor pressure.

1.3 Objectives/Purpose

The objectives of this study were to quantify the response of leaf gas exchange properties (e.g., net CO_2 assimilation rate, stomatal conductance) to environmental conditions in the field and to determine diurnal and seasonal changes in leaf gas exchange properties.

1.4 Summary of Parameters

Each data record includes the date and time of measurements, leaf properties (species, leaf area, boundary layer conductance, leaf temperature, net CO_2 assimilation rate, stomatal conductance, internal CO_2 concentration), and environmental conditions (PPFD, air temperature, CO_2 concentration, relative humidity, air vapor pressure).

1.5 Discussion

Our overall project goal was to investigate the surface-atmosphere exchange of carbon dioxide and methane, and the associated energy fluxes, at the SSA-Fen site. Leaf-level gas exchange measurements were made in the field on the dominant vascular plant species growing at the SSA-Fen site. Our primary focus was on Betula pumila (bog birch) and Menyanthes trifoliata (buckbean) based on the relative abundance (as reflected in, e.g., leaf area index (LAI)) of these species in the fen. A limited set of measurements was also made on Carex (sedge) species, mostly Carex diandra.

1.6 Related Data Sets

BOREAS TF-11 SSA-Fen Tower Flux and Meteorological Data
BOREAS TF-11 SSA-Fen 1996 Water Surface Film Capping Data
BOREAS TF-11 SSA-Fen Soil Surface CO2 Flux Data
BOREAS TF-11 SSA-Fen 1995 Leaf Area Index Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. Timothy J. Arkebauer, Associate Professor
Department of Agronomy
University of Nebraska-Lincoln

Dr. Shashi B. Verma, Professor
Department of Agricultural Meteorology
University of Nebraska-Lincoln

2.2 Title of Investigation

Field Micrometeorological Measurements, Process-Level Studies and Modeling of Methane and Carbon Dioxide Fluxes in a Boreal Wetland Ecosystem

2.3 Contact Information

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3. Theory of Measurements

Most gas exchange measurements were made by using an LI-6200 system in the closed-circuit mode. The net CO_2 assimilation rate is calculated via the change in CO_2 concentration in the sample chamber with time. Stomatal conductance is calculated from the rate of change of water vapor concentration with time, the fraction of the total system flow through the desiccant, and the (previously determined) boundary layer conductance of the leaf. Further details can be found in the LI-6200 Technical Reference Manual (LI-COR, Inc., 1990).

Measurements were also made with an LI-6400 system operated in the open mode. Here, the net CO_2 assimilation rate is calculated via the difference between the CO_2 concentration entering and exiting the sample chamber. Similarly, the stomatal conductance is a function of the water vapor concentrations entering and exiting the sample chamber, in conjunction with the boundary layer conductance of the leaf. Further details can be found in the LI-6400 Technical Reference Manual (LI-COR, Inc., 1995).

In all cases, the internal CO_2 concentrations of the leaves were calculated based on the measured net CO_2 assimilation rates and leaf conductances. Additional information on the theory related to leaf gas exchange measurements can be found in Ball (1987).

4. Equipment

4.1 Instrument Description

Most of the measurements were made with an LI-6200 Portable Photosynthesis System. Several measurements were made with a prototype LI-6400 Portable Photosynthesis System.

4.1.1 Collection Environment

All measurements were made on intact plants in the field at the SSA-Fen site under ambient environmental conditions.

4.1.2 Source/Platform

Measurements were made from platforms or boardwalks raised approximately 0.2 m above the fen surface.

4.1.3 Source/Platform Mission Objectives

None given.

4.1.4 Key Variables

Leaf properties: net CO_2 assimilation rate, stomatal conductance, internal CO_2 concentration, leaf temperature. Environmental conditions: air temperature, air vapor pressure, incident PPFD, air CO_2 concentration.

4.1.5 Principles of Operation

The LI-6200 was operated in the closed mode. Net CO_2 assimilation rate was determined from the time rate of change of CO_2 concentration in the sample chamber. Stomatal conductance was determined from the time rate of change of water vapor concentration in the chamber, in conjunction with the fraction of the system flow diverted through the desiccant and the (previously determined) leaf boundary layer conductance. CO_2 concentrations were measured with an infrared gas analyzer (IRGA). A pump circulated the air from the sample chamber, through the analyzer, and back into the sample chamber. Water vapor concentrations in the sample chamber were determined by a Vaisala humidity chip and a thermistor sensing the air temperature. Leaf temperatures were determined by a thermocouple pair that measured the temperature difference between the air thermistor and a thermocouple appressed to the leaf.

The LI-6400 was operated in the open mode. Net CO_2 assimilation rate was determined from the difference between the CO_2 concentration entering and exiting the sample chamber. Stomatal conductance was determined by the difference between the water vapor concentrations entering and exiting the chamber. Both CO_2 and water vapor concentrations were measured with a pair of IRGAs.

Additional information can be found in the LI-COR LI-6200 and LI-6400 Technical Reference manuals.

4.1.6 Sensor/Instrument Measurement Geometry

None given.

4.1.7 Manufacturer of Instrument

LI-COR, Inc.
P.O. Box 4425
4421 Superior Street
Lincoln, NE 68504 USA
(402) 467-3576
(402) 467-2819 (fax)

4.2 Calibration

4.2.1 Specifications

The IRGAs, the humidity chips, the flow meters, and the quantum sensors were calibrated by the manufacturer prior to each field season. The zero and span of the LI-6200 CO_2 analyzer and the zeros and spans of the LI-6400 CO_2 and water vapor analyzers were calibrated against known standard gases in the field.

4.2.1.1 Tolerance

None given.

4.2.2 Frequency of Calibration

Annual calibration of the IRGAs, the humidity chips, the flow meters, and the quantum sensors was done by the manufacturer. Daily calibration of the zero and span of the IRGAs in the field. The CO_2 zero and the flow meter zero were checked and adjusted several times daily.

4.2.3 Other Calibration Information

Calibration gases for the IRGAs were obtained from Acklands, 1042 Quebec Ave., Saskatoon, Saskatchewan CANADA, S7K 1V5 (Primary supplier: Linde gas, Alberta, CANADA). These gases were calibrated against gases of known concentration traceable to the National Oceanic and Atmospheric Administration (NOAA), Boulder, CO.

The LI-6400 water vapor analyzer span was calibrated using an LI-610 Dew Point Generator (LI-COR, Inc., Lincoln, NE 68504).

5. Data Acquisition Methods

A positive net CO_2 assimilation rate (e.g., photosynthesis) means that the net flux of CO_2 is into the leaf. A negative net CO_2 assimilation rate (e.g., respiration) indicates the net flux of CO_2 is out of the leaf.

Measurements of Betula and Menyanthes were made on single leaves (or portions of single leaves). For Carex measurements, several (typically 10 to 12) leaves were taped together, and the resulting rectangular area was placed in the sample chamber.

The LI-6200 measurements were made with a 0.25-liter sample chamber. Most measurements were made on plants growing adjacent to either the main (eddy correlation) boardwalk or raised platforms located approximately 200 m north and south of the main boardwalk. Most measurements were made under natural illumination (sunlight); however, a limited number of measurements were made with a red light emitting diode (LED) light source in conjunction with a LI-6400 gas exchange system. Leaves to be measured were placed in the sample chamber without altering their original orientation. The sample chamber was held with a tripod standing on the fen surface. Light response curves were usually made by attenuating natural illumination with neutral density filters. Respiration rates were determined after enclosing leaves in an opaque film-changing bag. Assimilation rates versus internal CO_2 concentration responses were determined using a transient technique with an LI-6200 gas exchange system. The net CO_2 assimilation rate and the internal CO_2 concentrations for these studies were corrected for chamber leaks, and an external fan was used to moderate chamber temperatures (for details see McDermitt et al., 1989). Leaf areas for irregularly shaped leaves (e.g., most of the Betula samples) were determined by tracing the leaf outline on ruled graph paper.

6. Observations

6.1 Data Notes

None given.

6.2 Field Notes

A limited set of field notes and observations is available by request from T.J. Arkebauer.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

Most measurements were made on plants growing adjacent to either the main (eddy correlation) boardwalk or raised platforms located approximately 200 m from the eddy correlation instrumentation, north and south of the main boardwalk. The North American Datum of 1983 (NAD83) corner coordinates of the SSA-Fen site are:

Site	Longitude	Latitude	BOREAS X	BOREAS Y
SSA-Fen	104.61798° W	53.80206° N	419.527	330.991

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

Not applicable.

7.1.4 Projection
These data were collected at point locations.

7.1.5 Grid Description
None.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
Measurements were made from 08-Jun through 07-Sep-1994 and 30-Jun through 06-Aug-1995.

7.2.2 Temporal Coverage Map
None.

7.2.3 Temporal Resolution
None given.

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
INSTRUMENT_NUM
GENUS
LEAF_ID
LEAF_AREA
STUDY_TYPE
OBS_NUM
ELAPSED_TIME_INIT
DOWN_PPFD_CHAMBER
LEAF_TEMP
AIR_TEMP_CHAMBER
CO2_CONC_CHAMBER
AIR_FLOW_CHAMBER
REL_HUM_CHAMBER
VAPOR_PRESS_CHAMBER
CO2_ASSIMILATION
STOMATAL_MOLAR_CONDUCT_H2O
INTERCELL_CO2_CONC
BOUND_LAYER_MOLAR_CONDUCT_H2O
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.
INSTRUMENT_NUM	The instrument number used for the measurement. If = 6400, the LI-COR 6400 was used. Otherwise, the LI-COR 6200 was used and the number indicates the LI-COR 6200 file number.
GENUS	The genus of the plant sample, where Betula= Betula pumila, Menyanthes=Menyanthes trifoliata, and Carex=Carex sp. (primarily Carex diandra).
LEAF_ID	The unique leaf identifier, within a day.
LEAF_AREA	The area of the leaf (or needles) enclosed in the chamber, this value is always half the total surface area of the sample.
STUDY_TYPE	An indicator of the type of study being conducted. Pn=net photosynthesis, Lr=light response curve, Rd=dark respiration, Aci=net CO2 assimilation versus internal CO2 concentration curve, Vr=vapor pressure deficit response. Note: these are not mutually exclusive designations.
OBS_NUM	The observation number.
ELAPSED_TIME_INIT	The elapsed time since the initiation of the measurement indicated by the observation time.
DOWN_PPFD_CHAMBER	The incoming photosynthetic photon flux density measured in the chamber.
LEAF_TEMP	The leaf or shoot temperature
AIR_TEMP_CHAMBER	The temperature of the air in the chamber.
CO2_CONC_CHAMBER	The CO2 concentration of the air in the chamber.
AIR_FLOW_CHAMBER	The total air flow rate through the system.
REL_HUM_CHAMBER	The relative humidity of the air in the chamber.
VAPOR_PRESS_CHAMBER	Vapor pressure of the air in the chamber.
CO2_ASSIMILATION	CO2 assimilation on leaf area basis
STOMATAL_MOLAR_CONDUCT_H2O	Stomatal conductance of water vapor.
INTERCELL_CO2_CONC	Intercellular CO2 concentration.
BOUND_LAYER_MOLAR_CONDUCT_H2O	The boundary layer conductance for water vapor of the sample.

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]
INSTRUMENT_NUM	[unitless]
GENUS	[none]
LEAF_ID	[unitless]
LEAF_AREA	[millimeter^2]
STUDY_TYPE	[none]
OBS_NUM	[unitless]
ELAPSED_TIME_INIT	[seconds]
DOWN_PPFD_CHAMBER	[micromoles][meters^-2][second^-1]
LEAF_TEMP	[degrees Celsius]
AIR_TEMP_CHAMBER	[degrees Celsius]
CO2_CONC_CHAMBER	[parts per million]
AIR_FLOW_CHAMBER	[micromoles][second ^-1]
REL_HUM_CHAMBER	[percent]
VAPOR_PRESS_CHAMBER	[millibars]
CO2_ASSIMILATION	[micromoles CO2][meter^-2][second^-1]
STOMATAL_MOLAR_CONDUCT_H2O	[millimoles H2O][meter^-2][second^-1]
INTERCELL_CO2_CONC	[parts per million]
BOUND_LAYER_MOLAR_CONDUCT_H2O	[moles H2O][meter^-2][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 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.]
INSTRUMENT_NUM	[Supplied by Investigator.]
GENUS	[Supplied by Investigator.]
LEAF_ID	[Supplied by Investigator.]
LEAF_AREA	[Supplied by Investigator.]
STUDY_TYPE	[Supplied by Investigator.]
OBS_NUM	[Supplied by Investigator.]
ELAPSED_TIME_INIT	[Supplied by Investigator.]
DOWN_PPFD_CHAMBER	[Supplied by Investigator.]

```
LEAF_TEMP                       [Supplied by Investigator.]
AIR_TEMP_CHAMBER                [Supplied by Investigator.]
CO2_CONC_CHAMBER                [Supplied by Investigator.]
AIR_FLOW_CHAMBER                [Supplied by Investigator.]
REL_HUM_CHAMBER                 [Supplied by Investigator.]
VAPOR_PRESS_CHAMBER             [Supplied by Investigator.]
CO2_ASSIMILATION                [Supplied by Investigator.]
STOMATAL_MOLAR_CONDUCT_H2O      [Supplied by Investigator.]
INTERCELL_CO2_CONC              [Supplied by Investigator.]
BOUND_LAYER_MOLAR_CONDUCT_H2O   [Supplied by Investigator.]
CRTFCN_CODE                     [Assigned by BORIS.]
REVISION_DATE                   [Assigned by BORIS.]
```

7.3.5 Data Range

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

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	SSA-FEN-FLXTR	SSA-FEN-FLXTR	None	None	None	None
SUB_SITE	9TF11-LFC01	9TF11-LFC01	None	None	None	None
DATE_OBS	08-JUN-94	06-AUG-95	None	None	None	None
TIME_OBS	2	2355	None	None	None	None
INSTRUMENT_NUM	29	6400	None	None	None	None
GENUS	N/A	N/A	None	None	None	None
LEAF_ID	1	24	None	None	None	None
LEAF_AREA	225	2540	None	None	None	None
STUDY_TYPE	ACi	Vr	None	None	None	None
OBS_NUM	1	635	None	None	None	None
ELAPSED_TIME_INIT	-1.516	9259	None	None	None	None
DOWN_PPFD_CHAMBER	-2.274	9658	-999	None	None	None
LEAF_TEMP	8.24	45.97	None	None	None	None
AIR_TEMP_CHAMBER	9.844	37.27	-999	None	None	None
CO2_CONC_CHAMBER	2.73	605.2	None	None	None	None
AIR_FLOW_CHAMBER	-9.65	1123	None	None	None	None
REL_HUM_CHAMBER	-2.75	99.85	-999	None	None	None
VAPOR_PRESS_CHAMBER	-2.098	46.85	-999	None	None	None
CO2_ASSIMILATION	-5.724	40.76	-999	None	None	None
STOMATAL_MOLAR_ CONDUCT_H2O	-4502	7537	-999	None	None	None
INTERCELL_CO2_CONC	-3164	18330	-999	None	None	None
BOUND_LAYER_MOLAR_ CONDUCT_H2O	.9	2.87	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	14-APR-99	14-APR-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. The data is arranged as comma-separated variables with the following information in each record.

```
SITE_NAME,SUB_SITE,DATE_OBS,TIME_OBS,INSTRUMENT_NUM,GENUS,LEAF_ID,LEAF_AREA,
STUDY_TYPE,OBS_NUM,ELAPSED_TIME_INIT,DOWN_PPFD_CHAMBER,LEAF_TEMP,
AIR_TEMP_CHAMBER,CO2_CONC_CHAMBER,AIR_FLOW_CHAMBER,REL_HUM_CHAMBER,
VAPOR_PRESS_CHAMBER,CO2_ASSIMILATION,STOMATAL_MOLAR_CONDUCT_H2O,
INTERCELL_CO2_CONC,BOUND_LAYER_MOLAR_CONDUCT_H2O,CRTFCN_CODE,REVISION_DATE
'SSA-FEN-FLXTR','9TF11-LFC01',08-JUN-94,1722,78,'Betula',1,416.0,'Pn',1,7.271,
1695.0,30.61,30.27,329.3,174.3,24.33,10.48,8.655,156.7,217.2,1.37,'CPI',14-APR-99
'SSA-FEN-FLXTR','9TF11-LFC01',08-JUN-94,1741,79,'Betula',2,290.0,'Pn',1,7.357,
2153.0,32.67,31.49,347.0,179.2,24.33,11.24,13.55,213.0,214.0,1.37,'CPI',14-APR-99
```

8. Data Organization

8.1 Data Granularity

The smallest unit of data that can be ordered from this data set is the entire set of data.

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

Formulae for calculating the net CO_2 assimilation rates, stomatal conductances, and internal CO_2 concentrations are given in the LI-6200 and LI-6400 Technical Reference Manuals.

9.1.1 Derivation Techniques/Algorithms

None given.

9.2 Data Processing Sequence

9.2.1 Processing Steps

- The BOREAS Information System (BORIS) received data from TF-11.
- BORIS standardized the units and loaded data into the data base.
- BORIS extracted data from data base into ASCII files.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Correction/Adjustments

None.

9.3.2 Calculated Variables

None.

9.4 Graphs and Plots

None.

10. Errors

10.1 Sources of Error

Calibration drift: The flow meter zero and IRGA CO_2 zero exhibited occasional drifts. The zeros were set periodically throughout the day.

Dew/wetness: When leaves were wet, the stomatal conductance and internal CO_2 values may not be correct. Examples of spurious data include conductances less than zero and CO_2 concentrations in the thousands.

10.2 Quality Assessment

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

BORIS staff loaded the data into the data base and checked for any inconsistencies during loading. Certain data records were found to have unrealistic values in some of the columns. In cases where these large values prevented these records from being loaded (i.e., they did not fit in the data base column), the values were changed to -999. Only 36 records were found to have this kind of problem.

11. Notes

11.1 Limitations of the Data

None given.

11.2 Known Problems with the Data

Other than the few times measurements were made on moist leaves (as discussed above), there are no known problems with the data set.

11.3 Usage Guidance

The normal caveat of 'use at your own risk' applies. Correspondence with T.J. Arkebauer is encouraged when questions arise.

A positive net CO_2 assimilation rate (e.g., photosynthesis) means that the net flux of CO_2 is into the leaf. A negative net CO_2 assimilation rate (e.g., respiration) indicates the net flux of CO_2 is out of the leaf.

11.4 Other Relevant Information

Dr. Evan C. Jolitz was responsible for most of the day to day coordination of the field measurements. His assistance is greatly appreciated. We also thank LI-COR, Inc., for their generous contribution of the prototype LI-6400 gas exchange system.

12. Application of the Data Set

These data can be used to better understand the leaf carbon dioxide flux at a typical fen in the boreal forest.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description

None given.

14.2 Software Access

None given.

15. Data Access

The SSA-Fen leaf gas exchange 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-6200 Technical Reference Manual. March 1990. LI-COR, Inc., Lincoln, NE, USA.

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17.2 Journal Articles and Study Reports

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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.

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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.

Suyker, A.E., S.B. Verma, and T.J. Arkebauer. 1997. Season-long measurement of carbon dioxide exchange in a boreal fen. Journal of Geophysical Research 102 (D24): 29,021-29,028.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

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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
IFC       - Intensive Field Campaign
IRGA      - Infrared Gas Analyzer
LAI       - Leaf Area Index
LED       - Light Emitting Diode
NAD83     - North American Datum of 1983
NASA      - National Aeronautics and Space Administration
NOAA      - National Oceanic and Atmospheric Administration
NSA       - Northern Study Area
ORNL      - Oak Ridge National Laboratory
PANP      - Prince Albert National Park
PPFD      - Photosynthetic Photon Flux Density
SSA       - Southern Study Area
TF        - Tower Flux
URL       - Uniform Resource Locator
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13. ABSTRACT *(Maximum 200 words)*

The BOREAS TF-11 team gathered a variety of data to complement its tower flux measurements collected at the SSA-Fen site. This data set contains single-leaf gas exchange data from the SSA-Fen site during 1994 and 1995. These leaf gas exchange properties were measured for the dominant vascular plants using portable gas exchange systems. The data are stored in tabular ASCII files.

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