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

Forrest G. Hall and Andrea Papagno, Editors

Volume 130
BOREAS TE-2 Continuous Wood Respiration Data

M.G. Ryan and M. Lavigne

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

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BOREAS TE-2 Continuous Wood Respiration Data

Michael G. Ryan, Michael Lavigne

Summary

The BOREAS TE-2 team collected several data sets in support of its efforts to characterize and interpret information on the respiration of the foliage, roots, and wood of boreal vegetation. This data set contains measurements of wood respiration measured continuously (about once per hour) in the NSA during the growing season of 1994. The data are stored in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS TE-02 Continuous Wood Respiration Data

1.2 Data Set Introduction

Field studies of wood respiration were measured continuously on tree stems by an automated manifold for 3-6 days per Intensive Field Campaign (IFC) at the BOReal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA) in 1994.

1.3 Objectives/Purpose

The objectives of the work were to:

- Determine whether respiratory parameters vary among three boreal tree species (black spruce, jack pine, and trembling aspen).
- Compare respiration parameters from the cold northern sites with those from the warmer, southern sites.
- Provide estimates of respiratory parameters for ecosystem process models.
- Use our estimates of wood respiration, estimates of wood biomass, and wood temperature throughout the year to estimate the annual carbon cost for wood respiration.

1.4 Summary of Parameters

Each data record includes flow to chamber (ml/minute) @STP (101.300 KPa pressure and 0 °C), air temperature (°C), sapwood temperature (°C), CO_2 reference (µL/L), CO_2 difference (µL/L), air pressure (mbar), µmol/m^2 bark/s (10^{-6} mol/m^2 bark/s), and error codes. **Error codes include:**

- Air Temperature < -5 or > 40 Degrees Celsius
- CO_2 Difference < 0 PPM
- CO_2 Reference < 345 Or > 600 PPM
- Large Change In CO_2 Ref Over Measurement Period
- Low Return Flow From Chamber
- Manifold Temperature < -5 Or > 35 Degrees Celsius
- Sapwood Temperature < -5 Or > 35 Degrees Celsius

1.5 Discussion

In the NSA, the Terrestrial Ecology (TE)-02 team measured continuous wood respiration rates for Old Aspen (OA) (Populus tremuloides), Old Black Spruce (OBS) (Picea mariana), Old Jack Pine (OJP) (Pinus banksiana), and Young Jack Pine (YJP) in 1994 during June, July, and August--corresponding with the BOREAS IFCs. These rates were used to estimate:

- the response of CO_2 evolution from wood to wood temperature,
- any lag in wood CO_2 efflux and wood temperature
- the relationship between wood temperature and air temperature.

1.6 Related Data Sets

BOREAS TE-02 Foliage Respiration Data
BOREAS TE-02 Root Respiration Data
BOREAS TE-02 Stem Growth and Sapwood Data
BOREAS TE-02 Wood Respiration Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. Michael G. Ryan
Dr. Michael Lavigne

2.2 Title of Investigation

Autotrophic Respiration in Boreal Ecosystems

2.3 Contact Information

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3. Theory of Measurements

Respiration oxidizes sugars, producing energy, water, and CO_2--and absorbing oxygen. In most plant cells, the ratio between the oxygen absorbed and CO_2 produced in respiration is close to one. Therefore, because small changes in CO_2 concentration in the air are easier to measure than small changes in the oxygen content of the air, respiration is typically measured as CO_2 evolution from plant tissues. CO_2 evolution is typically measured with an infrared gas analyzer (IRGA), operating in one of three modes: open, closed, or differential. The system that we used to measure stem wood respiration was an open system, which estimates molar flux of CO_2 from plant tissue respiration as the difference between the CO_2 concentration entering and exiting the chamber times the molar flow rate of air through the chamber (Field et al., 1991). Respiration of woody tissues is estimated as the CO_2 efflux at the boundary of the bark-air interface. Respiration rates are typically expressed as moles CO_2 per m^2 bark area per second. We assembled a sampling manifold to sequentially sample the CO_2 efflux from eight trees, once per hour.

Respiration of woody tissues will vary with temperature and sapwood volume, and perhaps with sapwood nitrogen, phosphorus, or carbohydrate content. Sampling for nitrogen, phosphorus, or carbohydrate content or determining sapwood cross-sectional area of a stem involves destructive measurements. Therefore, samples are generally taken after the respiration measurements have been completed. These characteristics are stored in a separate file and documented in TE-02 Stem Growth Sapwood Data.

4. Equipment

4.1 Instrument Description

4.1.1 Collection Environment

Respiration measurements were made in the field. All other measurements took place under laboratory conditions.

4.1.2 Source/Platform

None given.

4.1.3 Source/Platform Mission Objectives

Not applicable.

4.1.4 Key Variables

Each data record includes flow to chamber (ml/minute) @STP (101.300 KPa pressure and 0 °C), air temperature (°C), sapwood temperature (°C), CO_2 reference (µL/L), CO_2 difference (µL/L), air pressure (mbar), µmol/m^2 bark/s (10^{-6} mol/m^2 bark/s), and error codes. Error codes include:

- Air Temperature < -5 or > 40 Degrees Celsius
- CO_2 Difference < 0 PPM
- CO_2 Reference < 345 Or > 600 PPM
- Large Change In CO_2 Ref Over Measurement Period
- Low Return Flow From Chamber
- Manifold Temperature < -5 Or > 35 Degrees Celsius
- Sapwood Temperature < -5 Or > 35 Degrees Celsius

4.1.5 Principles of Operation

The continuous measurements were made using a manifold and an open system (Field et al., 1991), controlled with a CR-21X datalogger (Campbell Scientific, Logan, UT, USA). The manifold system had two separate gas circuits: when CO_2 efflux was being measured, inlet air was drawn through a 20-L mixing chamber (to provide a stable reference CO_2 concentration), passed through the chamber at 270 µmol/s, and returned to the CO_2 analyzer (ADC LCA2, ADC, Hoddeston, UK). Otherwise, inlet air was pushed through the chambers at 3.5 mmol/s (controlled with a mass flow controller), to keep CO_2 concentration in the chamber at < 5 µmol/mol above ambient. CO_2 efflux for each of eight chambers was sampled every 5 seconds for 8 minutes, and only the last minute's average data used for analysis and stored in the data base. The remaining data were discarded because they represent nonequilibrium conditions. Methods are similar to those described in Ryan et al. (1995) and are more fully described in Lavigne and Ryan (1997). For IFC-3 in NSA-OA, some of the chambers were covered with aluminum foil for 2-3 days to estimate refixation by bark photosynthesis.

4.1.6 Sensor/Instrument Measurement Geometry

None.

4.1.7 Manufacturer of Instrument

Ryan built the sampling manifold.

IRGA
LCA2
Analytical Development Company (ADC)
Hoddeston, Herts., UK
Distributed by:
Dynamax, Inc.
10808 Fallstone
Suite 350
Houston, TX 77099 USA
(281) 564-5100

CR-21X datalogger
Campbell Scientific, Inc.
815 West 1800 North
Logan, UT 84321-1784
(435) 753-2342
(435) 750-9540 (fax)
support@campbellsci.com

4.2 Calibration

4.2.1 Specifications

We calibrated the IRGA to a concentration standard supplied by BOREAS prior to a measurement period for each IFC. Typically, the analyzer will drifted less than 2% between calibrations.

4.2.1.1 Tolerance

We calibrated the IRGA to a concentration standard supplied by BOREAS prior to a measurement period for each IFC. Typically, the analyzer drifted less than 2% between calibrations.

4.2.2 Frequency of Calibration

We calibrated the IRGA to a concentration standard supplied by BOREAS prior to a measurement period for each IFC. Typically, the analyzer drifted less than 2% between calibrations.

4.2.3 Other Calibration Information

We calibrated the molar flow through the mass flow controller roughly every month with a bubble column. We used standard meteorological pressure (reported at Thompson), corrected for elevation, and temperature from a copper-constantan thermocouple to calculate molar flow from the volume flow for this calculation.

5. Data Acquisition Methods

Continuous stem respiration was measured on eight trees at OJP, OBS, and OA sites in the NSA, once per IFC, and on six trees at YJP in NSA (only IFC-2). Tree diameters spanned the range of the stand. At the OJP, OBS, and OA sites, aluminum chamber plates with an external neoprene gasket were attached to the north side of the tree with putty; loose bark was removed before attaching the chamber plate. Chambers were at 1.2-1.4 m height and at 6 m. For CO_2 efflux measurements, a Plexiglas chamber was sealed to the chamber plate with an elastic cord. The chamber area for OA, OBS, and OJP was 110 cm^2. That is counting 1/2 of the plate area (assuming 1/2 of the flux under the plate goes into the chamber and 1/2 does not). The area inside the chamber is 80.5 cm^2. For measurements at YJP, split Plexiglas chambers (23 cm in length) enclosed the entire stem, with neoprene gaskets creating a seal. A small fan mixed the air in each chamber, and chambers were removed between measurements. Temperatures were measured at each tree.

6. Observations

6.1 Data Notes

None.

6.2 Field Notes

None.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The measurement sites and associated North American Datum of 1983 (NAD83) coordinates are:

- OA canopy access, site id T2Q6A, Lat/Long: 55.88691°N, 98.67479°W, Universal Transverse Mercator (UTM) Zone 14, N: 6,193,540.7, E: 520,342
- OBS canopy access tower, site id T3R8T, Lat/Long: 55.88007°N, 98.48139°W, UTM Zone 14, N: 6,192,853.4, E: 532,444.5
- OJP, site id T7Q8T, Lat/Long: 55.92842°N, 98.62396°W, UTM Zone 14, N: 6,198,176.3, E: 523,496.2
- YJP, site id, T8S9T, Lat/Long: 55.89575°N, 98.28706°W, UTM Zone 14, N: 6,194,706.9, E: 544,583.9

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

These data are point source measurements at the given locations.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

We measured continuous wood respiration in 1994 during June, July, and August--corresponding with the BOREAS IFCs 1, 2, and 3 at NSA-OBS, NSA-OJP, and NSA-OA. Continuous measurements were made at NSA-YJP during IFC-2.

7.2.2 Temporal Coverage Map

Each IFC at the OJP, OBS, and OA sites, CO_2 efflux was measured once per hour for 3-6 days on eight chambers (four trees at 1.3 and 6 m) to determine temperature response; at YJP, continuous measurements were made for six trees only during the midsummer IFC. Point measurements of CO_2 flux were made every 2-3 weeks at all sites for all chambers.

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
```

SAMPLE_ID
CHAMBER_HEIGHT
SPECIES
MEAN_AIR_TEMP_1MIN
MEAN_SAP_TEMP_1MIN
MEAN_CO2_REFERENCE_1MIN
MEAN_CO2_DIFFERENCE_1MIN
AIR_FLOW_THROUGH_CHAMBER_STP
MANIFOLD_ATMOSPHERIC_PRESS
MEAN_CO2_FLUX_CHAMBER_1MIN
ERROR_CODE_FLAGS
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, YRN, 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.
SAMPLE_ID	The sample identifier used by data collectors (see documentation for a detailed description).
CHAMBER_HEIGHT	The height above the ground at which the chamber was placed.
SPECIES	Botanical (Latin) name of the species (Genus species).
MEAN_AIR_TEMP_1MIN	The air temperature averaged over one minute.
MEAN_SAP_TEMP_1MIN	The sapwood temperature averaged over one minute
MEAN_CO2_REFERENCE_1MIN	The CO2 concentration of the air entering the chamber averaged over one minute.
MEAN_CO2_DIFFERENCE_1MIN	The difference between the CO2 reference and the CO2 concentration of the air exiting the chamber averaged over one minute.
AIR_FLOW_THROUGH_CHAMBER_STP	The mean volume of air flowing through the chamber per minute at 0 degrees Celsius and one atmosphere pressure.
MANIFOLD_ATMOSPHERIC_PRESS	The atmospheric pressure at the sampling manifold.
MEAN_CO2_FLUX_CHAMBER_1MIN	The chamber CO2 flux of the bark averaged over

	one minute.
ERROR_CODE_FLAGS	The error code associated with the data.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

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

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
SAMPLE_ID	[none]
CHAMBER_HEIGHT	[meters]
SPECIES	[none]
MEAN_AIR_TEMP_1MIN	[degrees Celsius]
MEAN_SAP_TEMP_1MIN	[degrees Celsius]
MEAN_CO2_REFERENCE_1MIN	[parts per million]
MEAN_CO2_DIFFERENCE_1MIN	[parts per million]
AIR_FLOW_THROUGH_CHAMBER_STP	[milliliter][minute^-1]
MANIFOLD_ATMOSPHERIC_PRESS	[KiloPascals]
MEAN_CO2_FLUX_CHAMBER_1MIN	[micromoles][meter^-2][second^-1]
ERROR_CODE_FLAGS	[none]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

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

Column Name	Data Source
SITE_NAME	[BORIS Designation]
SUB_SITE	[BORIS Designation]
DATE_OBS	[Human Observer]
TIME_OBS	[Human Observer]
SAMPLE_ID	[Human Observer]
CHAMBER_HEIGHT	[Human Observer]
SPECIES	[Human Observer]
MEAN_AIR_TEMP_1MIN	[Thermometer]
MEAN_SAP_TEMP_1MIN	[Thermometer]
MEAN_CO2_REFERENCE_1MIN	[Laboratory Equipment]
MEAN_CO2_DIFFERENCE_1MIN	[Laboratory Equipment]
AIR_FLOW_THROUGH_CHAMBER_STP	[Laboratory Equipment]
MANIFOLD_ATMOSPHERIC_PRESS	[Laboratory Equipment]
MEAN_CO2_FLUX_CHAMBER_1MIN	[Laboratory Equipment]
ERROR_CODE_FLAGS	[Human Observer]
CRTFCN_CODE	[BORIS Designation]
REVISION_DATE	[BORIS Designation]

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-9OA-9TETR	NSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TE02-WRC01	9TE02-WRC01	None	None	None	None
DATE_OBS	29-MAY-94	22-SEP-94	None	None	None	None
TIME_OBS	0	2359	None	None	None	None
SAMPLE_ID	N/A	N/A	None	None	None	None
CHAMBER_HEIGHT	1.3	6	None	None	None	None
SPECIES	N/A	N/A	None	None	None	None
MEAN_AIR_TEMP_1MIN	-2.9	42.2	-999	None	None	None
MEAN_SAP_TEMP_1MIN	-5.3	40.2	-999	None	None	None
MEAN_CO2_REFERENCE_1MIN	296.5	748.3	-999	None	None	None
MEAN_CO2_DIFFERENCE_1MIN	-2.1	355.5	-999	None	None	None
AIR_FLOW_THROUGH_CHAMBER_STP	313	568	-999	None	None	None
MANIFOLD_ATMOSPHERIC_PRESS	96.6	99.2	None	None	None	None
MEAN_CO2_FLUX_CHAMBER_1MIN	-.004	2.931	-999	None	None	None
ERROR_CODE_FLAGS	N/A	N/A	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	06-NOV-98	06-NOV-98	None	None	None	None

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

Blank -- Indicates that blank spaces are used to denote that type of value.
N/A -- Indicates that the value is not applicable to the respective column.

```
None  -- Indicates that no values of that sort were found in the column.
-------------------------------------------------------------------------------
```

7.4 Sample Data Record

The following are wrapped versions of data record from a sample data file on the CD-ROM.

```
SITE_NAME,SUB_SITE,DATE_OBS,TIME_OBS,SAMPLE_ID,CHAMBER_HEIGHT,SPECIES,
MEAN_AIR_TEMP_1MIN,MEAN_SAP_TEMP_1MIN,MEAN_CO2_REFERENCE_1MIN,
MEAN_CO2_DIFFERENCE_1MIN,AIR_FLOW_THROUGH_CHAMBER_STP,
MANIFOLD_ATMOSPHERIC_PRESS,MEAN_CO2_FLUX_CHAMBER_1MIN,ERROR_CODE_FLAGS,
CRTFCN_CODE,REVISION_DATE
'NSA-OJP-FLXTR','9TE02-WRC01',29-MAY-94,2032,'2',1.3,'Pinus banksiana',9.1,10.5,
374.9,10.1,401.0,97.1,.274,'','CPI',06-NOV-98
'NSA-OJP-FLXTR','9TE02-WRC01',29-MAY-94,2032,'2',1.3,'Pinus banksiana',9.1,10.5,
374.9,10.1,401.0,97.1,.274,'','CPI',06-NOV-98
```

8. Data Organization

8.1 Data Granularity

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

8.2 Data Format(s)

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

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

9. Data Manipulations

9.1 Formulae

None.

9.1.1 Derivation Techniques and Algorithms

None given.

9.2 Data Processing Sequence

None given.

9.2.1 Processing Steps

None given.

9.2.2 Processing Changes

None given.

9.3 Calculations

9.3.1 Special Corrections/Adjustments
Not applicable.

9.3.2 Calculated Variables
Not applicable.

9.4 Graphs and Plots
Not applicable.

10. Errors

10.1 Sources of Error
Sample trees were selected to represent the range of variability in respiration rates. Because the IRGA could typically resolve a difference in concentration of CO_2 of one µmol/mol, lower respiration rates have more uncertainty in the measurement.

10.2 Quality Assessment
Flux rates of CO_2 are likely to be accurate within +/- 5 percent.

10.2.1 Data Validation by Source
Data from the manifold were checked for internal consistency and against single chamber measurements with a portable gas analyzer, and potential errors were flagged. Error codes are listed in Sections 1.4 and 4.1.4 and in the data file.

10.2.2 Confidence Level/Accuracy Judgment
None given.

10.2.3 Measurement Error for Parameters
Flux rates of CO_2 are likely to be accurate within +/- 5 percent. Temperature of wood is likely to be accurate within +/- 0.3 °C.

10.2.4 Additional Quality Assessments
None given.

10.2.5 Data Verification by Data Center
Data were examined for general consistency and clarity.

11. Notes

11.1 Limitations of the Data
None given.

11.2 Known Problems with the Data
Processing Notes and missing data (also times for foil covering trees for the OA site in IFC-3):

NSA Site	Tree	Position	1994 Date	GMT Time	Problem
OA	1	2	209	105	Bad Reference
OA	1	1	209	9	Bad Reference
OA	1	1	209	113	Bad Reference
OA	1	1	209	633	Bad Reference
OA	1	1	209	737	Bad Reference
OA	1	1	210	459	Bad Reference
OA	2	2	209	17	Bad Reference
OA	4	1	212	655	Bad Reference
OA	1	2	258	1600	Covered with foil until Day 260. No apparent response.
OA	1	1	258	1600	Covered with foil until Day 260. About 50% increase.
OA	2	2	258	1210	Low readings after, leak??, deleted all after.
OA	3	2	258	1530	Bad Reference
OA	3	2	258	1600	Covered with foil until Day 260
OA	3	2	260	1022	Bad Flux
OA	3	1	258	1600	Covered with foil until Day 260
OA	4	1	257	31	Bad Flux
OA	4	1	258	1354	Bad Reference
OBS	1	2	261	1219	Bad Reference
OBS	1	1	263	711	Bad Reference
OBS	1	1	263	815	Bad Reference
OBS	2	2	261	1131	Bad Flux
OBS	2	2	261	1235	Bad Flux
OBS	2	2	265	2011	Bad Flux
OBS	2	1	263	102	Bad Reference
OBS	2	1	265	1147	Bad Flux
OBS	3	2	265	1051	Bad Flux
OBS	3	2	265	1155	Bad Flux
OBS	3	1	263	743	Bad Flux
OBS	3	1	263	847	Bad Flux
OBS	3	1	265	1202	Bad Flux
OBS	3	1	265	1515	Bad Flux
OBS	4	2	261	1203	Bad Flux
OBS	4	2	265	1419	Bad Flux
OBS	4	1	261	1107	High Flux at low temps
OBS	4	1	261	1211	High Flux at low temps
OBS	4	1	263	759	High Flux at low temps
OBS	4	1	263	903	High Flux at low temps
OBS	4	1	265	1010	High Flux at low temps
OBS	4	1	265	1115	High Flux at low temps
OBS	4	1	265	1427	High Flux at low temps
OJP	2	1	151	1931	Bad Reference
OJP	4	1	150	2258	Bad Reference
OJP	4	2	151	1923	Bad Reference
OJP	1	2	150-151	2300-2030	Bad Air Temp
OJP	1	1	150-151	2300-2030	Bad Air Temp
OJP	2	2	150-151	2300-2030	Bad Air Temp
OJP	2	1	150-151	2300-2030	Bad Air Temp
OJP	3	2	150-151	2300-2030	Bad Air Temp
OJP	3	1	150-151	2300-2030	Bad Air Temp

OJP	4	2	150-151	2300-2030	Bad Air Temp
OJP	4	1	150-151	2300-2030	Bad Air Temp
OJP	2	2	254	406	Bad Reference CO2
OJP	4	1	255	1809	Bad Sapwood Temperature
YJP	7	1	222	1005	Bad Reference CO2

11.3 Usage Guidance
None given.

11.4 Other Relevant Information
None given.

12. Application of the Data Set

These data can be used to study continuous wood respiration rates of boreal vegetation.

13. Future Modifications and Plans

None given.

14. Software

14.1 Software Description
None given.

14.2 Software Access
None given.

15. Data Access

The continuous wood respiration data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information
For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification
Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics
http://www-eosdis.ornl.gov/.

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

None.

16.2 Film Products

None.

16.3 Other Products

These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

None.

17.2 Journal Articles and Study Reports

Field, C.B., J.T. Ball, and J.A. Berry. 1991. Photosynthesis: principles and field techniques. In Plant Physiological Ecology, edited by R.W. Pearcy, J. Ehleringer, H.A. Mooney, and P.W. Rundel, Chapman and Hall, London, pp. 206-253.

Lavigne, M.B. and M.G. Ryan. 1997. Growth and maintenance respiration rates of aspen, black spruce and jack pine stems at northern and southern BOREAS sites. Tree Physiol., BOREAS Special Issue, 17:543-551.

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.

Ryan, M.G., S.T. Gower, R.M. Hubbard, R.H. Waring, H.L. Gholz, W.P. Cropper, and S.W. Running. 1995. Woody tissue maintenance respiration of four conifers in contrasting climates. Oecologia 101:133-140.

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

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102(D24): 28,731-28,770.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

STP - 101.300 KPa pressure and 0 °C

19. List of Acronyms

ADC - Analytical Development Company
ASCII - American Standard Code for Information Interchange
BOREAS - BOReal Ecosystem-Atmosphere Study
BORIS - BOREAS Information System
CD-ROM - Compact Disk-Read-Only Memory
CO_2 - Carbon Dioxide
DAAC - Distributed Active Archive Center
EOS - Earth Observing System
EOSDIS - EOS Data and Information System
GIS - Geographic Information System
GMT - Greenwich Mean Time
GSFC - Goddard Space Flight Center
HTML - HyperText Markup Language
IFC - Intensive Field Campaign
IRGA - Infrared Gas Analyzer
MIX - Mixed
NAD83 - North American Datum of 1983
NIR - Near Infrared Radiation
NOAA - National Oceanic and Atmospheric Administration
NSA - Northern Study Area
OA - Old Aspen
OBS - Old Black Spruce
OJP - Old Jack Pine
ORNL - Oak Ridge National Laboratory
PANP - Prince Albert National Park

PAR - Photosynthetically Active Radiation
PPFD - Photosynthetic Photon Flux Density
SSA - Southern Study Area
TE - Terrestrial Ecology
TF - Tower Flux site
URL - Uniform Resource Locator
UTM - Universal Transverse Mercator
YA - Young Aspen
YJP - Young Jack Pine

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13. ABSTRACT *(Maximum 200 words)*

The BOREAS TE-2 team collected several data sets in support of its efforts to characterize and interpret information on the respiration of the foliage, roots, and wood of boreal vegetation. This data set contains measurements of wood respiration measured continuously (about once per hour) in the NSA during the growing season of 1994. The data are stored in tabular ASCII files.

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