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

Forrest G. Hall and Shelaine Curd, Editors

Volume 136

BOREAS TE-5 CO_2 Concentration and Stable Isotope Composition

J. Ehleriinger, J.R. Brooks, and L. Flanagan

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

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BOREAS TE-5 CO_2 Concentration and Stable Isotope Composition

Jim Ehleringer, J.Renee Brooks, Larry Flanagan

Summary

The BOREAS TE-5 team collected measurements in the NSA and SSA on gas exchange, gas composition, and tree growth. This data set contains measurements of the concentration and stable carbon ($^{13}C/^{12}C$) and oxygen ($^{18}O/^{16}O$) isotope ratios of atmospheric CO_2 in air samples collected at different heights within forest canopies. The data were collected to determine the influence of photosynthesis and respiration by the forest ecosystems on the concentration and stable isotope ratio of atmospheric CO_2. These measurements were collected at the SSA during each 1994 IFC at OJP, OBS, and OA sites. Measurements were also collected at the NSA during each 1994 IFC at the OJP, T6R5S TE UBS, and T2Q6A TE OA sites. The stable isotope ratios are expressed using standard delta notation and in units of per mil. The isotope ratios are expressed relative to the international standard, PDB, for both carbon and oxygen samples. The data are stored in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS TE-05 CO_2 Concentration and Stable Isotope Composition

1.2 Data Set Introduction

These data consist of measurements of the concentration and stable carbon ($^{13}C/^{12}C$) and oxygen ($^{18}O/^{16}O$) isotope ratio of atmospheric CO_2 in air samples that were collected at different heights within forest canopies located in the BOReal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA) and Southern Study Area (SSA). The samples were collected over diurnal time courses at two heights (9 m and 0.5 m) during each Intensive Field Campaign (IFC) in black spruce,

jack pine, and aspen forest canopies in both the NSA and SSA during 1994.

The stable isotope ratios are expressed using standard delta notation and in units of per mil. The isotope ratios are expressed relative to the international standard, Pee Dee Belemnite (PDB), for both carbon and oxygen samples.

1.3 Objective/Purpose

The data were collected to determine the influence of photosynthesis and respiration by the forest ecosystems on the concentration and stable isotope ratio of atmospheric CO_2.

1.4 Summary of Parameters

- CO_2 concentration in air sample: ppm, e.g., 347.7
- Carbon isotope ratio of CO_2 in air sample: per mil, e.g., -8.04
- Oxygen isotope ratio of CO_2 in air sample: per mil, e.g., -0.62

1.5 Discussion

These measurements were collected at the SSA during each 1994 IFC at the Old Jack Pine (OJP), Old Black Spruce (OBS), and Old Aspen (OA) sites. Measurements were also collected at the NSA during each 1994 IFC at the OJP, T6R5S Terrestrial Ecology (TE) Upland Black Spruce (UBS), and T2Q6A TE OA sites. The stable isotope ratios are expressed using standard delta notation and in units of per mil. The isotope ratios are expressed relative to the international standard, PDB, for both carbon and oxygen samples.

1.6 Related Data Sets

BOREAS TE-05 Diurnal CO2 Canopy Profile Data
BOREAS TE-05 Leaf Gas Exchange Data
BOREAS TE-05 Leaf Carbon Isotope Data
BOREAS TE-05 Tree Ring and Carbon Isotope Ratio Data
BOREAS TE-05 Surface Meteorological and Radiation Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

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2.2 Title of Investigation

Vegetation-Atmosphere CO_2 and H_2O Exchange Processes: Stable Isotope Analyses

2.3 Contact Information

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3. Theory of Measurements

CO_2 concentration measurements were made using an infrared gas analyzer (IRGA) (LI 6250, LI-COR, Lincoln, NE). Theoretical details of the CO_2 measurements and instruments can be obtained from the manufacturer: LI-COR, Inc., P.O. Box 4425, 4421 Superior Street, Lincoln, NE 68504, USA, toll-free telephone 1 (800) 447-3576 (USA and Canada), telephone (402) 467-2819.

The carbon and oxygen isotope ratio measurements were done using a gas isotope ratio mass spectrometer (Sira 12, VG Isotech, Middlewich, Cheshire, UK) at the Ottawa-Carleton Stable Isotope Facility, University of Ottawa. This instrument was maintained by Gilles St. Jean, telephone (613) 562-5800 ext. 6836.

The stable isotope ratios are expressed using standard delta notation and in units of per mil. The isotope ratios are expressed relative to the international standard, PDB, for both carbon and oxygen samples.

4. Equipment

4.1 Sensor/Instrument Description

CO_2 concentration measurements were made using an IRGA (LI 6250, LI-COR, Lincoln, NE). Theoretical details of the CO_2 measurements and instruments can be obtained from LI-COR, Inc.

The carbon and oxygen isotope ratio measurements were done using a gas isotope ratio mass spectrometer (Sira 12, VG Isotech, Middlewich, Cheshire, UK) at the Ottawa-Carleton Stable Isotope Facility, University of Ottawa. This instrument was maintained by Gilles St. Jean, telephone (613) 562-5800 ext. 6836.

The stable isotope ratios are expressed using standard delta notation and in units of per mil. The isotope ratios are expressed relative to the international standard, PDB, for both carbon and oxygen samples.

4.1.1 Collection Environment

The equipment operated under ambient environmental conditions during the measurement periods. Please see TE-05 Surface Meteorological and Radiation Data for specifics.

4.1.2 Source/Platform

None given.

4.1.3 Source/Platform Mission Objectives

The mission objective was to monitor air stable isotope changes at different heights within the forest canopy.

4.1.4 Key Variables

Ratio $^{13}C/^{12}C$
Ratio $^{18}O/^{16}O$

4.1.5 Principles of Operation

None given.

4.1.6 Sensor/Instrument Measurement Geometry

None given.

4.1.7 Manufacturer of Sensor/Instrument

CO_2 concentration measurements were made using an IRGA (LI 6250, LI-COR, Lincoln, NE). Theoretical details of the CO_2 measurements and instruments can be obtained from the manufacturer: LI-COR, Inc., P.O. Box 4425, 4421 Superior Street, Lincoln, NE 68504, USA, toll-free telephone 1 (800) 447-3576 (USA and Canada), telephone (402) 467-2819.

The carbon and oxygen isotope ratio measurements were done using a gas isotope ratio mass spectrometer (Sira 12, VG Isotech, Middlewich, Cheshire, UK) at the Ottawa-Carleton Stable Isotope Facility, University of Ottawa. This instrument was maintained by Gilles St. Jean, telephone (613) 562-5800 ext. 6836.

4.2 Calibration

4.2.1 Specifications

None given.

4.2.1.1 Tolerance

None given.

4.2.2 Frequency of Calibration

None given.

4.2.3 Other Calibration Information

The IRGA of the LI-6250 infrared analyzer was calibrated using primary standard gas mixtures from Matheson Gas. These gas mixtures were calibrated relative to BOREAS project calibration standards.

The calibration of the gas isotope ratio mass spectrometer (Sira 12, VG Isotech, Middlewich, Cheshire, UK) at the Ottawa-Carleton Stable Isotope Facility, University of Ottawa, was done by Gilles St. Jean, telephone (613) 562-5800 ext. 6836.

The stable isotope ratios are expressed using standard delta notation and in units of per mil. The isotope ratios are expressed relative to the international standard, PDB, for both carbon and oxygen samples.

5. Data Acquisition Methods

At each site, samples of air within the forest canopy were collected at intervals during a 2- to 3-day period on three separate dates during the summer of 1994. Sample lines (Bev-a-line or Dekoron tubing, 6-mm outer diameter, Warehoused Plastic Sales, Toronto, Ontario, Canada) were located at different heights in the canopy (9 m and 0.5 m) by attachment to a 9-m mast (Rohn E20 telescoping mast). An inverted funnel was connected to the inlet to prevent water from entering the tubing, and a small filter was placed over the inlet to prevent the entry of insects. Air was pulled down through the tubing, through a desiccant tube (6200DP, LI-COR, Lincoln, NE, USA) containing magnesium perchlorate, and into glass flasks (either 1.7 or 2.0 liter) by a battery-operated pump (TD-4N pump, Brailsford & Co., Inc., Rye, NY, USA) on the ground approximately 10 m away from the mast. The flasks were evacuated prior to sampling (see extracting CO_2 below)and contained no CO_2 before they were opened after being attached to the sampling line. The CO_2 concentration of the air was measured using an IRGA (LI-6250 CO_2 analyzer, LI-COR, Lincoln, NE, USA). Air was passed through the flasks for approximately 20 minutes before a CO_2 concentration measurement was recorded and the high vacuum stopcocks on the flask were closed. The flask was then returned to a lab for cryogenic extraction of the CO_2.

In order to extract CO_2, air sample flasks were attached to a stainless steel vacuum line that consisted of two ethanol-dry ice traps to remove water vapor, and two liquid nitrogen traps to collect CO_2. After evacuating the vacuum line to less than 10-3 Torr, the vacuum pump (E2M8 rotary pump, Edwards High Vacuum, Burlington, Ontario, Canada) was isolated from the line by closing a valve, and a stopcock on a sample flask was opened to allow the sample gases to enter the vacuum line. The needle valve isolating the pump from the vacuum line was then opened slightly to slowly remove the incondensable gases. After the vacuum returned to 10-3 Torr, the two traps containing the CO_2 were isolated by closing toggle valves. The purified CO_2 was released by warming the traps to the temperature of an ethanol-dry ice bath, and the CO_2 was transferred to a tube, connected to a side-arm of the vacuum line, and sealed with a torch. The flame-sealed tubes were stored until stable isotope analysis was performed. The CO_2 from forest air samples was analyzed on a gas isotope ratio mass spectrometer (Sira 12, VG Isotech, Middlewich, Cheshire, UK) at the Ottawa Carleton Stable Isotope Facility.

The stable isotope ratios are expressed using standard delta notation and in units of per mil. The isotope ratios are expressed relative to the international standard, PDB, for both carbon and oxygen samples.

6. Observations

6.1. Data Notes

None given.

6.2 Field Notes

None given.

7. Data Description

7.1 Spatial Characteristics

- NSA OJP: Lat/Long = 55.92°N, 98.62°W.
- NSA UBS (T6R5S): Lat/Long = 55.70°N, 98.51°W.
- NSA OA (T2Q6A): Lat/Long = 55.88°N, 98.67°W.
- SSA OJP: Lat/Long = 53.91°N, 104.69°W.
- SSA OBS: Lat/Long = 53.98°N, 105.12°W.
- SSA OA: Lat/Long = 53.62°N, 106.19°W.

7.1.1 Spatial Coverage

Samples were collected at NSA OJP, SSA OJP, SSA OBS, and NSA UBS in 1993 and all the sites listed below in 1994. The North American Datum of 1983 (NAD83) coordinates of the sites are:

- NSA OJP flux tower site: Lat/Long = 55.927°N, 98.62°W, UTM Zone 14, N:6,197,997 E:523,501.
- NSA OA canopy access tower site: auxiliary site number T2Q6A, BOREAS Experiment Plan, Version 3. Lat/Long = 55.88691°N, 98.67479°W, UTM Zone 14, N:6193540.7 E:520342.
- NSA UBS canopy access tower site: auxiliary site number T6R5S, BOREAS Experiment Plan, Version 3. Lat/Long = 55.90802°N, 98.51865°W, UTM Zone 14 N:6195947, E:530092.
- SSA OA flux tower site: Lat/Long = 53.629°N, 106.197°W, UTM Zone 13, N:5,942,688 E:420,874.
- SSA OJP flux tower site: Lat/Long = 53.916°N, 104.69°W, UTM Zone 13, N:5,951,000 E:479,400.
- SSA OBS flux tower site, Lat/Long: 53.985°N, 105.122°W. UTM Zone 13, N:5,981,904 E:492,000.

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

These data represent point source measurements from the sites shown.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

These measurements were collected at the SSA during each 1994 IFC at OJP, OBS, and OA sites. Collection of data occurred during 25-May-1994 to 08-Sep-1994. Measurements were also collected at the NSA during each 1994 IFC at the OJP, UBS, and OA sites. Collection of data occurred during 02-Jun-1994 to 06-Sep-1994.

7.2.2 Temporal Coverage Map

- NSA OJP: 02-Jun-1994, 7.32 Greenwich Mean Time (GMT) through 03-Jun-1994, 16.32 (GMT).
- NSA OA: 10-Jun-1994,16.15 (GMT) through 11-Jun-1994, 19.98 (GMT).
- NSA UBS: 03-Jun-1994, 2.15 (GMT) through 04-Jun-1994, 2.15 (GMT).
- SSA OA: 29-May-1994,1900 (GMT) through 30-May-1994, 2150 (GMT).
- SSA OBS: 25-May-1994, 1.50 (GMT) through 27-May-1994, 20.00 (GMT).
- SSA OJP: 25-May-1994, 2050 (GMT) through 27-May-1994, 2.00 (GMT).

- NSA OJP: 20-Jul-1994, 21.48 (GMT) through 24-Jul-1994, 22.32 (GMT).
- NSA OA: 31-Jul-1994, 17.82 (GMT) through 05-Aug-1994, 20.98 (GMT).
- NSA UBS: 25-Jul-1994, 20.15 (GMT) through 29-Jul-1994, 22.48 (GMT).
- SSA OA: 25-Jul-1994, 1900 (GMT) through 27-Jul-1994, 17.50 (GMT).
- SSA OBS: 20-Jul-1994 20.50 (GMT) through 22-Jul-1994, 15.50 (GMT).
- SSA OJP: 22-Jul-1994, 2.50 (GMT) through 24-Jul-1994, 18.00 (GMT).

- NSA OJP: 30-Aug-1994, 18.65 (GMT) through 01-Sep-1994, 21.15 (GMT).
- NSA OA: 05-Sep-1994, 19.32 (GMT) through 07-Sep-1994, 18.65 (GMT).
- NSA UBS: 02-Sep-1994, 18.48 (GMT) through 04-Sep-1994, 16.15 (GMT).
- SSA OA: 03-Aug-1994, 17.50 (GMT) through 05-Aug-1994, 18.00 (GMT).
- SSA OBS: 31-Aug-1994, 18.50 (GMT) through 02-Aug-1994, 17.50 (GMT).
- SSA OJP: 06-Aug-1994, 18.00 (GMT) through 08-Aug-1994, 18.50 (GMT).

7.2.3 Temporal Resolution

Each site was visited three times during 1994. Measurements were reported in 2-hour intervals.

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
HT_AGL
CO2_CONC
ISOTOPE_13C
ISOTOPE_18O
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.
HT_AGL	The height above ground at which the measurements were taken.
CO2_CONC	CO2 concentration.
ISOTOPE_13C	Carbon 13/12 isotope ratio.
ISOTOPE_18O	Oxygen 18/16 isotope ratio.
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]
HT_AGL	[meters]
CO2_CONC	[parts per million]
ISOTOPE_13C	[per mil]
ISOTOPE_18O	[per mil]
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	[BORIS Designation]
SUB_SITE	[BORIS Designation]
DATE_OBS	[Human Observer]
TIME_OBS	[Human Observer]
HT_AGL	[Laboratory Equipment]
CO2_CONC	[Laboratory Equipment]
ISOTOPE_13C	[Laboratory Equipment]
ISOTOPE_18O	[Laboratory Equipment]
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-9BS-9TETR	SSA-OJP-FLXTR	None	None	None	None
SUB_SITE	9TE05-AIS01	9TE05-AIS01	None	None	None	None
DATE_OBS	25-MAY-94	08-SEP-94	None	None	None	None
TIME_OBS	0	2358	None	None	None	None
HT_AGL	.5	9	None	None	None	None
CO2_CONC	331.7	705	None	None	None	None
ISOTOPE_13C	-16.93	-6.49	None	None	None	None
ISOTOPE_18O	-8.99	3.1	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	03-SEP-97	03-SEP-97	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,HT_AGL,CO2_CONC,ISOTOPE_13C,ISOTOPE_18O,
CRTFCN_CODE,REVISION_DATE
'NSA-9BS-9TETR','9TE05-AIS01',02-JUN-94,325,.5,371.0,-9.02,-.5,'CPI',03-SEP-97
'NSA-9BS-9TETR','9TE05-AIS01',02-JUN-94,328,9.0,359.0,-8.1,.14,'CPI',03-SEP-97
'NSA-9BS-9TETR','9TE05-AIS01',03-JUN-94,25,9.0,352.8,-7.61,.01,'CPI',03-SEP-97
```

8. Data Organization

8.1 Data Granularity

The smallest unit of orderable data is data collected on one day at one site.

8.2 Data Format

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

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

9. Data Manipulations

9.1 Formulae

None.

9.1.1 Derivation Techniques and Algorithms

None.

9.2 Data Processing Sequence

9.2.1 Processing Steps

None.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments
None.

9.3.2 Calculated Variables
None.

9.4 Graphs and Plots
None.

10. Errors

10.1 Sources of Error
All known errors have been removed from the data.

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
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
None given.

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 compare stable isotope data between the NSA and the SSA. Stable isotope ratios can help determine the ages of the trees being sampled.

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 CO_2 concentration and stable isotope composition 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

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

Brooks, J.R., L.B. Flanagan, and J.R. Ehleringer. 1998. Responses of boreal conifers to climate fluctuations: indications from tree-ring widths and carbon isotope analyses. Can. J. For. Res. 28: in press.

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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 Exchange
BOREAS  - BOReal Ecosystem-Atmosphere Study
BORIS   - BOREAS Information System
CD-ROM  - Compact Disk-Read-Only Memory
DAAC    - Distributed Active Archive Center
EOS     - Earth Observing System
EOSDIS  - EOS Data and Information System
GIS     - Geographic Information System
GMT     - Greenwich Mean Time
GSFC    - Goddard Space Flight Center
HTML    - HyperText Markup Language
IFC     - Intensive Field Campaign
IRGA    - Infrared Gas Analyzer
NASA    - National Aeronautics and Space 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
PDB     - Per Dee Belemnite
TE      - Terrestrial Ecology
SSA     - Southern Study Area
UBS     - Upland Black Spruce
URL     - Uniform Resource Locator
UTM     - Universal Transverse Mercator
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13. ABSTRACT *(Maximum 200 words)*

The BOREAS TE-5 team collected measurements in the NSA and SSA on gas exchange, gas composition, and tree growth. This data set contains measurements of the concentration and stable carbon ($^{13}C/^{12}C$) and oxygen ($^{18}O/^{16}O$) isotope ratios of atmospheric CO_2 in air samples collected at different heights within forest canopies. The data were collected to determine the influence of photosynthesis and respiration by the forest ecosystems on the concentration and stable isotope ratio of atmospheric CO_2. These measurements were collected at the SSA during each 1994 IFC at OJP, OBS, and OA sites. Measurements were also collected at the NSA during each 1994 IFC at the OJP, T6R5S TE UBS, and T2Q6A TE OA sites. The stable isotope ratios are expressed using standard delta notation and in units of per mil. The isotope ratios are expressed relative to the international standard, PDB, for both carbon and oxygen samples. The data are stored in tabular ASCII files.

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