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

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BOREAS TE-5 CO₂ Concentration and Stable Isotope Composition

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BOREAS TE-5 CO₂ 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 (13C/12C) and oxygen (18O/16O) isotope ratios of atmospheric CO₂ 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 CO₂. 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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1. Data Set Overview

1.1 Data Set Identification
BORAEAS TE-05 CO₂ Concentration and Stable Isotope Composition

1.2 Data Set Introduction
These data consist of measurements of the concentration and stable carbon (13C/12C) and oxygen (18O/16O) isotope ratio of atmospheric CO₂ in air samples that were collected at different heights within forest canopies located in the BORreal 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 CO₂.

1.4 Summary of Parameters

• CO₂ concentration in air sample: ppm, e.g., 347.7
• Carbon isotope ratio of CO₂ in air sample: per mil, e.g., -8.04
• Oxygen isotope ratio of CO₂ 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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TE-05
Department of Biology
Salt Lake City, UT 84112

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TE-05
Department of Biology
1125 Colonel By Drive
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2.2 Title of Investigation

Vegetation-Atmosphere CO₂ and H₂O Exchange Processes: Stable Isotope Analyses
2.3 Contact Information

Contact 1: (Contact for NSA Data)
J. Renee Brooks
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University of South Florida
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larry.flanagan@uleth.ca

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Greenbelt, MD 20771
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shelaine.curd@gsfc.nasa.gov

3. Theory of Measurements

CO₂ concentration measurements were made using an infrared gas analyzer (IRGA) (LI 6250, LI-COR, Lincoln, NE). Theoretical details of the CO₂ 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

CO₂ concentration measurements were made using an IRGA (LI 6250, LI-COR, Lincoln, NE). Theoretical details of the CO₂ 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

CO₂ concentration measurements were made using an IRGA (LI 6250, LI-COR, Lincoln, NE). Theoretical details of the CO₂ 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 CO₂ below) and contained no CO₂ before they were opened after being attached to the sampling line. The CO₂ concentration of the air was measured using an IRGA (LI-6250 CO₂ analyzer, LI-COR, Lincoln, NE, USA). Air was passed through the flasks for approximately 20 minutes before a CO₂ 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 CO₂.

In order to extract CO₂, 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 CO₂. 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 CO₂ were isolated by closing toggle valves. The purified CO₂ was released by warming the traps to the temperature of an ethanol-dry ice bath, and the CO₂ 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 CO₂ 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 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.
- 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
- SSA OJP: 22-Jul-1994, 2.50 (GMT) through 24-Jul-1994, 18.00 (GMT).
- SSA OA: 03-Aug-1994, 17.50 (GMT) through 05-Aug-1994, 18.00 (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:

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7.3.2 Variable Description/Definition

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

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<tr>
<th>Column Name</th>
<th>Description</th>
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<td>SITE_NAME</td>
<td>The identifier assigned to the site by BOREAS, in the format SSS-TTT-CCCCC,</td>
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<tr>
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<td>where SSS identifies the portion of the study area: NSA, SSA, REG, TRN,</td>
</tr>
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<td></td>
<td>and TTT identifies the cover type for the site, 999 if unknown, and</td>
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<td></td>
<td>CCCCC is the identifier for site, exactly what it means will vary with</td>
</tr>
<tr>
<td></td>
<td>site type.</td>
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<tr>
<td>SUB_SITE</td>
<td>The identifier assigned to the sub-site by BOREAS, in the format GGGGG-III</td>
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<td></td>
<td>IIII, where GGGGG is the group associated with the sub-site instrument, e.g.</td>
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<td>HYD06 or STAFF, and IIIII is the identifier for sub-site, often this will</td>
</tr>
<tr>
<td></td>
<td>refer to an instrument.</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>The date on which the data were collected.</td>
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<tr>
<td>TIME_OBS</td>
<td>The Greenwich Mean Time (GMT) when the data were collected.</td>
</tr>
<tr>
<td>HT_AGL</td>
<td>The height above ground at which the measurements were taken.</td>
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<tr>
<td>CO2_CONC</td>
<td>CO2 concentration.</td>
</tr>
<tr>
<td>ISOTOPE_13C</td>
<td>Carbon 13/12 isotope ratio.</td>
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<tr>
<td>ISOTOPE_18O</td>
<td>Oxygen 18/16 isotope ratio.</td>
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<td>The BOREAS certification level of the data. Examples are CPI (Checked by PI</td>
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<td>), CGR (Certified by Group), PRE (Preliminary), and CPI-?? (CPI but</td>
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<td>questionable).</td>
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<td>REVISION_DATE</td>
<td>The most recent date when the information in the referenced data base table</td>
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<td>record was revised.</td>
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7.3.3 Unit of Measurement

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7.3.4 Data Source
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7.3.5 Data Range
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</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>SITE_NAME, SUB_SITE, DATE_OBS, TIME_OBS, HT_AGL, CO2_CONC, ISOTOPE_13C, ISOTOPE_18O, CRTFCN_CODE, REVISION_DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>'NSA-9BS-9TETR', '9TE05-AIS01', 02-JUN-94, 325, .5, 371.0, -9.02, - .5, 'CPI', 03-SEP-97</td>
</tr>
<tr>
<td>'NSA-9BS-9TETR', '9TE05-AIS01', 02-JUN-94, 328, 9.0, 359.0, -8.1, .14, 'CPI', 03-SEP-97</td>
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<tr>
<td>'NSA-9BS-9TETR', '9TE05-AIS01', 03-JUN-94, 25, 9.0, 352.8, -7.61, .01, 'CPI', 03-SEP-97</td>
</tr>
</tbody>
</table>

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 CO₂ 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

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


17.3 Archive/DBMS Usage Documentation
None.

18. Glossary of Terms
None.

19. List of Acronyms

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
20. Document Information

20.1 Document Revision Date
Written: 03-May-1995
Last Updated: 02-Jun-1999

20.2 Document Review Date(s)
BORIS Review: 10-Jun-97
Science Review:

20.3 Document ID

20.4 Citation
When using these data, please contact the investigators listed in Section 2.3 as well as citations of relevant papers in Section 17.2.

If using data from the BOREAS CD-ROM series, also reference the data as:

Also, cite the BOREAS CD-ROM set as:

20.5 Document Curator

20.6 Document URL
**4. TITLE AND SUBTITLE**

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

BOREAS TE-5 CO₂ Concentration and Stable Isotope Composition

**6. AUTHOR(S)**

Jim Ehleringer, J. Renee Brooks and Larry Flanagan

Forrest G. Hall and Shelaine Curd, Editors

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS (ES)**

Goddard Space Flight Center
Greenbelt, Maryland 20771

**8. PERFORMING ORGANIZATION REPORT NUMBER**

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Washington, DC 20546-0001

**12a. DISTRIBUTION / AVAILABILITY STATEMENT**

Unclassified—Unlimited

Subject Category: 43

Report available from the NASA Center for AeroSpace Information, 7121 Standard Drive, Hanover, MD 21076-1320. (301) 621-0390.

**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 (¹³C/¹²C) and oxygen (³¹⁰O/¹⁶O) isotope ratios of atmospheric CO₂ 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 CO₂. 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.

**14. SUBJECT TERMS**

BOREAS, terrestrial ecology, atmospheric CO₂.

**15. NUMBER OF PAGES**

15

**16. PRICE CODE**

20. LIMITATION OF ABSTRACT

UL

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