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

Forrest G. Hall and Shelaine Curd, Editors

Volume 142
BOREAS TE-5 Tree Ring and Carbon Isotope Ratio Data

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

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

October 2000

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BOREAS TE-5 Tree Ring and Carbon Isotope Ratio Data

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National Aeronautics and
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Available from:

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Hanover, MD 21076-1320
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5285 Port Royal Road
Springfield, VA 22161
Price Code: A10

BOREAS TE-5 Tree Ring and Carbon Isotope Ratio Data

Jim Ehleringer, J.Renee Brooks, Larry Flanagan

Summary

The BOREAS TE-5 team collected several data sets to investigate the vegetation-atmosphere CO_2 and H_2O exchange processes. These data include tree ring widths and cellulose carbon isotope data from coniferous trees collected at the BOREAS NSA and SSA in 1993 and 1994 by the BOREAS TE-05 team. Ring width data are provided for both Picea mariana and Pinus banksiana. The carbon isotope data are provided only for Pinus banksiana. The data are provided in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS TE-05 Tree Ring and Carbon Isotope Ratio Data

1.2 Data Set Introduction

Tree ring widths were collected from trees from Old Black Spruce (OBS) in the BOReal Ecosystem-Atmosphere Study (BOREAS) Southern Study Area (SSA), Upland Black Spruce (UBS) in the Northern Study Area (NSA), and Old Jack Pine (OJP) in the SSA and the NSA. The carbon isotope ratio of cellulose was measured on individual tree rings from 1974 to 1994 for the OJP sites, two trees from each site.

1.3 Objective/Purpose

The purpose of this study was to measure year-to-year variation in ring widths and carbon isotope ratios in the conifers at the northern and southern sites. These data were compared with year-to-year variations on meteorological measurements in an attempt to find whether variables have influenced both diameter growth and carbon isotope discrimination. Investigators studied whether controlling climate variables were the same in the north as in the south.

1.4 Summary of Parameters and Variables
Annual ring widths (mm)
Carbon isotope ratios

1.5 Discussion
Tree cores were collected at both the NSA and SSA in both 1993 and 1994 at the OJP, OBS, and OBS (T6R56) sites. These data can be compared to determine differences in growth rates and possible effects of climate variables during the time frame recorded by tree ring widths. The tree ring isotope data ranges can be used to determine the relative concentration of C isotopes based on knowing the relative assimilation by trees at different sites.

1.6 Related Data Sets
BOREAS TE-05 Diurnal CO2 Canopy Profile Data
BOREAS TE-05 Leaf Carbon Isotope Data

International tree ring data base (http://tree.ltrr.arizona.edu/~grissino/itrdb.htm)

2. Investigator(s)

2.1 Investigator(s) Name and Title
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SIRFER
Dept. of Biology
University of Utah

Dr. Larry Flanagan
Department of Biological Sciences
University of Lethbridge

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

Annual variation in tree ring width represents variation in stem growth. Annual variation in delta ^{13}C of cellulose represents the annual variation of carbon isotope discrimination by the tree. For complete information on stable carbon isotope ratios, see Coleman and Fry (1991). The stable carbon isotope ratio ($^{13}C/^{12}C$) is not presented as an absolute but as the relative difference between the isotope ratios of the sample and standard gases: delta ^{13}C (o/oo) = ((Rsample / Rstandard) -1) * 1000, where Rsample and Rstandard are the $^{13}C/^{12}C$ ratios of the plant sample and standard Pee Dee Belemite (PDB). The overall precision of the measurements of cellulose materials was ± 0.11 o/oo.

4. Equipment

4.1 Sensor/Instrument Description

Isotope ratio mass spectrometer (delta S, Finnigan Mat, San Jose, CA). Measuring stage for tree ring widths (Fred C. Henson, Mission Viego, CA).

4.1.1 Collection Environment

NSA and SSA black spruce and jack pine sites. Carbon isotopes of cellulose were measured only for the last 20 years of growth (1994-1974).

4.1.2 Source/Platform

Dominant conifer trees, which were considered to be those trees that were clearly taller than the surrounding trees, were chosen.

4.1.3 Source/Platform Mission Objectives

The purpose of this study was to understand the relationship between environmental variables and annual variation in tree ring widths and carbon isotope ratios.

4.1.4 Key Variables

Year
Annual ring widths (mm)
Annual cellulose carbon isotope ratios

4.1.5 Principles of Operation

None.

4.1.6 Sensor/Instrument Measurement Geometry

Not applicable.

4.1.7 Manufacturer of Sensor/Instrument

Mass spectrometer:
Finnigan Mat
355 River Oaks Parkway
San Jose, CA 95134
(404) 424-5284

Measuring stage:
Fred C. Henson Co.
28362 Marguerite Parkway
Mission Viego, CA 92691-1523
(714) 831-9192

4.2 Calibration

Ring width calibration: Calibration on the measuring stage was checked prior to each use. The nature of the measuring stage is such that the calibration is extremely stable and no adjustments were ever needed.

Carbon isotope calibration: The mass spectrometer is calibrated to standard PDB gas. This international standard was a limestone of fossil Belemnitella Americana from the Cretaceous Pee Dee formation in South Carolina. In addition, a standard cellulose sample was run after every 12 cellulose samples.

4.2.1 Specifications

None.

4.2.1.1 Tolerance

Annual ring widths:
Precision: 0.01 mm
Carbon isotope ratio
Precision: 0.1

4.2.2 Frequency of Calibration

Mass spectrometer: 1 in every 12 samples was a cellulose standard. Mass spectrometers are maintained by Craig Cook at the University of Utah.
Measuring stage: Calibration was tested prior to every use.

4.2.3 Other Calibration Information

None.

5. Data Acquisition Methods

At each site, four to six dominant trees were cored or slabs were collected for analysis. All slabs and cores were collected at breast height (1.3 m). Slabs were collected from trees that were destructively harvested for biomass estimates (see other BOREAS Terrestrial Ecology (TE)-06 documentation). In the lab, slabs and cores were sanded so that tree rings were clearly visible. For each tree, ring widths were measured from two directions and averaged together. Prior to measuring ring widths, tree rings were counted along both measuring directions and checked to ensure that each count was the same. Skeletal plots were created for each tree and compared for all trees within a plot to ensure comparable dating for all the trees. Aging these trees was very straightforward from diameter at breast height (dbh); however, it was understated that this is not the absolute age of the tree because time and growth were needed for the tree to reach dbh (for more details see: Cook and Kairiukstis, 1990). Each tree ring chronology begins at the last year of growth (1993 or 1994, depending on when the sample was collected) and ends at the year the tree reached 1.3 m (center of the slab).

Carbon isotopes of cellulose were measured only for the last 20 years of growth (1994-1974). To collect enough cellulose material for isotope analyses, only tree slabs were used. For each year, sample material was collected from four sides of the slab to ensure annual uniformity. Tree rings were carefully separated using an exacto knife while viewed under a 40x dissecting scope. Care was taken to include tissue only from the year of interest in the sample. Cellulose was extracted from the wood samples following the method outlined in Leavitt and Danzer (1992). Cellulose samples were then analyzed on the mass spectrometer for delta ^{13}C.

6. Observations

6.1 Data Notes
None given.

6.2 Field Notes
None given.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage
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; Universal Transverse Mercator (UTM) Zone 14, N:6,197,997 E:523,501.
- SSA-OJP flux tower site: Lat/Long:53.916°N, 104.69°W: UTM Zone 13, N:5,951,000 E:479,400.
- NSA-UBS canopy access tower site (auxiliary site number T6R5S, BOREAS Experiment Plan, Version 3).
- 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 measurements of the sampled trees that may be representative of a larger area.

7.1.4 Projection
Not applicable.

7.1.5 Grid Description
Not applicable.

7.2 Temporal Characteristics
Not applicable.

7.2.1 Temporal Coverage
Ring width measurements:
NSA-OJP: 1994-1939
NSA-UBS (T6R5S): 1994-1944

SSA-OJP: 1994-1902
SSA-OBS: 1994-1867

Carbon isotope data:
NSA-OJP and SSA-OJP: 1994-1974

7.2.2 Temporal Coverage Map
Not applicable.

7.2.3 Temporal Resolution
Annual.

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
START_DATE
END_DATE
SPECIES
TREE_RING_YEAR
TREE
TREE_RING_WIDTH
CELLULOSE_DELTA_C13
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.
START_DATE	The date on which the collection of data commenced.
END_DATE	The date on which the collection of the data was terminated.
SPECIES	Botanical (Latin) name of the species (Genus

	species).
TREE_RING_YEAR	The year of the tree ring growth.
TREE	The individual tree from which measurements were taken.
TREE_RING_WIDTH	The width of the tree ring growth.
CELLULOSE_DELTA_C13	Relative difference of the C13 isotope between the sample and a standard.
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]
START_DATE	[DD-MON-YY]
END_DATE	[DD-MON-YY]
SPECIES	[none]
TREE_RING_YEAR	[none]
TREE	[none]
TREE_RING_WIDTH	[millimeters]
CELLULOSE_DELTA_C13	[unitless]
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]
START_DATE	[Human Observer]
END_DATE	[Human Observer]
SPECIES	[Human Observer]
TREE_RING_YEAR	[Human Observer]
TREE	[Human Observer]
TREE_RING_WIDTH	[Human Observer]
CELLULOSE_DELTA_C13	[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-TRC01	9TE05-TRC01	None	None	None	None
START_DATE	09-AUG-93	30-AUG-94	None	None	None	None
END_DATE	29-AUG-93	19-SEP-94	None	None	None	None
SPECIES	N/A	N/A	None	None	None	None
TREE_RING_YEAR	1867	1994	None	None	None	None
TREE	A	I	None	None	None	None
TREE_RING_WIDTH	.04	4.815	None	None	None	None
CELLULOSE_DELTA_C13	-25.37	-22.11	None	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	12-AUG-97	12-AUG-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 is a sample of the first few records from the data table on the CD-ROM:

```
SITE_NAME,SUB_SITE,START_DATE,END_DATE,SPECIES,TREE_RING_YEAR,TREE,
TREE_RING_WIDTH,CELLULOSE_DELTA_C13,CRTFCN_CODE,REVISION_DATE
'NSA-9BS-9TETR','9TE05-TRC01',30-AUG-94,19-SEP-94,'Picea mariana',1957,
'D',1.63,,'CPI',12-AUG-97
'NSA-9BS-9TETR','9TE05-TRC01',30-AUG-94,19-SEP-94,'Picea mariana',1954,
'D',1.935,,'CPI',12-AUG-97
```

8. Data Organization

8.1 Data Granularity

The smallest unit of data tracked by the BOREAS Information System (BORIS) was that 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. Each row represents an annual record beginning with the year.

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.

10. Errors

10.1 Sources of Error

Other than normal background error associated with the instrumentation, there are no other sources of error. The overall precision of the measurements of cellulose materials was ± 0.11 o/oo.

10.2 Quality Assessment

None given.

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
Small sample sizes.

11.2 Known Problems with the Data
There are no known problems with the data.

11.3 Usage Guidance
None.

11.4 Other Relevant Information
None given.

12. Application of the Data Set

Tree ring and isotope data can be examined to determine previous climate conditions and how those conditions affect the growth of trees.

13. Future Modifications and Plans

None given.

14. Software

14.1 Software Description
The ITRDB Program Library Version 2.1 is the latest version of the ITRDB Program Library, an extensive collection of programs to acquire, manipulate, analyze, and display tree ring data; they are accompanied by extensive documentation, including online help, and run from an easy-to-use DOS-based menu. Henri D. Grissino-Mayer wrote many of the programs as well as the main menu, Richard L. Holmes contributed the famous Dendrochronology Program Library, and Edward R. Cook contributed the standardization program ARSTAN. Other contributors include Thierry Varem-Sanders, Oriol Bosch, and Paul Krusic, and to them we are very grateful. If you or anybody you work with has developed software you feel would be useful to the entire dendrochronological community, contact Henri D. Grissino-Mayer to see about incorporating the programs in the Program Library.

14.2 Software Access
Software access -- http://tree.ltrr.arizona.edu/~grissino/software.htm
For tree ring data: (source: Henri Grissino-Mayer http://tree.ltrr.arizona.edu/~grissino/software.htm)

15. Data Access

The TE-05 tree ring and carbon isotope ratio 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

Coleman, D.C. and B. Fry. 1991. Carbon Isotope Techniques. Academic Press, San Diego, pp. 273.

Cook, E.R. and L.A. Kairiukstis. 1990. Methods of Dendrochronology: Applications in the Environmental Sciences. Kluwer Academic Publishers, Dordrecht, pp. 394.

Leavitt, S.W. and S.R. Danzer. 1992. Methods for batch processing small wood samples to holocellulose for stable-carbon isotope analysis. Anal. Chem. 65: 87-89.

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.

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).

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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.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

delta ^{13}C, or d^{13}C - stable carbon isotope ratio

19. List of Acronyms

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
dbh - Diameter at breast height
EOS - Earth Observing System
EOSDIS - EOS Data and Information System
GIS - Geographic Information System
GSFC - Goddard Space Flight Center
HTML - HyperText Markup Language
NASA - National Aeronautics and Space Administration
NSA - Northern Study Area
OBS - Old Black Spruce
OJP - Old Jack Pine
ORNL - Oak Ridge National Laboratory
PANP - Prince Albert National Park
SSA - Southern Study Area
UBS - Upland Black Spruce
URL - Uniform Resource Locator
UTM - Universal Transverse Mercator

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When using these data, please include the following acknowledgment as well as citations of relevant papers in Section 17.2:

The efforts of Jim Ehleringer, University of Utah; Larry Flanagan, Carleton University; and J. Renee Brooks, University of South Florida in collecting and providing these data are greatly appreciated.

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

Ehleringer, J. and L. Flanagan, " Vegetation-Atmosphere CO_2 and H_2O Exchange Processes: Stable Isotope Analyses." In Collected Data of The Boreal Ecosystem-Atmosphere Study. Eds. J. Newcomer, 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. CD-ROM. NASA, 2000.

Also, cite the BOREAS CD-ROM set as:

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. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM. NASA, 2000.

20.5 Document Curator

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The BOREAS TE-5 team collected several data sets to investigate the vegetation-atmosphere CO_2 and H_2O exchange processes. These data include tree ring widths and cellulose carbon isotope data from coniferous trees collected at the BOREAS NSA and SSA in 1993 and 1994 by the BOREAS TE-05 team. Ring width data are provided for both Picea mariana and Pinus banksiana. The carbon isotope data are provided only for Pinus banksiana. The data are provided in tabular ASCII files.

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