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

Forrest G. Hall and Sara K. Conrad, Editors

Volume 237

BOREAS TGB-8 Monoterpene Concentration Data over the SSA-OBS

M. Lerdau

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

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BOREAS TGB-8 Monoterpene Concentration Data over the SSA-OBS and the SSA-OJP

Manuel Lerdau

Summary

The BOREAS TGB-8 team collected data to investigate the controls over NMHC fluxes from boreal forest tree species. This data set contains measurements of monoterpene concentrations in collected foliar gas emissions and foliar samples. The data were collected at the OJP and OBS tower flux sites in the SSA and were the locus for the monoterpene emission measurements. These areas contained mature stands of jack pine and black spruce and were the focal sites in the BOREAS program for studies of biosphere/atmosphere exchange from these two habitat types. The OBS site is situated in a black spruce/sphagnum bog with the largest trees 155 years old and 10-15 m tall. The OJP site is in a jack pine forest, 80 to 120 years old, which lies on a sandy bench of glacial outwash with the largest tree standing 15 m tall. Temporally, the data cover the period of 24-May-1994 to 19-Sep-1994. The data are stored in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS TGB-08 Monoterpene Concentration Data over the SSA-OBS and the SSA-OJP

1.2 Data Set Introduction

This data set contains measurements of monoterpene concentrations in collected foliar gas emissions and foliar samples. The data were collected at the OJP and OBS tower flux sites in the SSA and were the locus for the monoterpene emission measurements. These areas contained mature stands of jack pine and black spruce and were the focal sites in the BOREAS program for studies of biosphere/atmosphere exchange from these two habitat types.

1.3 Objective/Purpose

The objective of this data set was to measure the monoterpene concentration in first fully expanded (second-year) needles from the BOReal Ecosystem-Atmosphere Study (BOREAS) Southern Study Area (SSA)-Old Black Spruce (OBS) and SSA-Old Jack Pine (OJP) sites.

1.4 Summary of Parameters

Monoterpene concentration and monoterpene emission.

1.5 Discussion

The research was ordered around three general questions: (1) To what extent are leaf carbon balance and isoprene synthase activity (the enzyme responsible for isoprene emission) predictors of nonmethane hydrocarbon (NMHC) flux? (2) How do leaf carbon balance and isoprene synthase activity depend on nitrogen/water availability and carbon source/sink parameters? and (3) How do we modify the FORES-BGC ecosystem model, based on question 1 and 2, to predict canopy-level NMHC fluxes? Studies included seasonal monitoring of NMHC emissions and its relationship to plant phenology, photosynthesis, respiration, isoprene synthase activity, and leaf starch concentrations.

1.6 Related Data Sets

BOREAS TGB-08 Photosynthetic Rate Data over the SSA-OBS and the SSA-OJP
BOREAS TGB-08 Starch Concentration Data over the SSA-OBS and the SSA-OJP
BOREAS TGB-09 Above-Canopy NMHC at SSA-OBS, SSA-OJP, and SSA-OA Sites
BOREAS TGB-10 Volatile Organic Carbon Data over the SSA
BOREAS TGB-10 Oxidant Concentration Data over the SSA
BOREAS TGB-10 Oxidant Flux Data over the SSA

2. Investigator(s)

2.1 Investigator(s) Name and Title

Manuel Lerdau

2.2 Title of Investigation

The Relationship Between Non-Methane Hydrocarbon Emission and Leaf Carbon Balance in the Boreal Forest: An Approach for Mechanistic Ecosystem Modeling

2.3 Contact Information

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Raytheon ITSS
Code 923
NASA GSFC
Greenbelt, MD 20771
(301) 286-7858
(301) 286-0239 (fax)
Jeffrey.Newcomer@gsfc.nasa.gov

3. Theory of Measurements

Sample Selection

For the photosynthesis/hydrocarbon measurements, 10 trees of each species were chosen that had sunlit leaves accessible within 3 m of the ground. All measurements were conducted on sunlit leaves that had developed the previous year. Tissue chemistry and gas exchange sampling on sunlit leaves from branches much higher in the canopy showed that there was no significant effect of branch height on photosynthetic rate or on tissue composition (ANOVA, $p>0.05$, data not shown). The black spruce trees used in the bog transect/tissue chemistry sampling were chosen on the basis of having sunlit leaves accessible within 2 m of the ground. All hydrocarbon measurements were made on fully expanded needles that had developed during the previous growing season. Needles were placed in the cuvette so that only those needles that expanded during the previous growing season were included. Needle age in all cases was determined unambiguously by marking needle cohorts before leaf expansion in the spring and by examining the branches for twig color change and bud scarring associated with each year's growth. The bog transect measurements were also all made on the previous year's fully expanded needles.

Sample Procedure

Hydrocarbon emissions: Samples were collected by enclosing branches in a temperature- and light-controlled cuvette connected to a plant gas exchange system (Campbell MPH 1000, Campbell Scientific, Logan, UT) and flowing hydrocarbon-free air over the needles. Temperature was controlled by use of thermoelectric coolers provided by Campbell Scientific, and light intensity was controlled by mounting a projector bulb at a right angle to the top of the glass-topped cuvette. The light was then reflected off of a cold mirror (45° cold mirror, 15-33233, OCLI, Santa Rosa, CA) mounted at a 45° angle to the cuvette. The mirror transmitted light at wavelengths >720 nm and reflected light of shorter wavelengths. Hydrocarbon-free air was produced by pumping ambient air through a clean-air generator (Aadco 5L, AADCO Instruments, Silver Springs, FL) and adding CO_2 back to the entering air stream. All flows and environmental conditions were monitored by the sensors and mass flow controllers of the Campbell MPH 1000. Hydrocarbon emission samples were collected by diverting a fraction of the air exiting the leaf cuvette through a sampling tube packed with a solid sorbent. Supelco Carbotrap 300 cartridges (Bellafonte, PA) with dimensions of 7-inch length and 1/4-inch outer diameter were used in this work. The sampling tubes were conditioned before each use via a Tekmar Thermo Trap unit (Cincinnati, OH) at 220 °C for a minimum of 4 hours at a flow of approximately 10 mL/min of ultrahigh purity nitrogen. A blank from each set of conditioned cartridges was analyzed to ensure that they had been properly cleaned. The flow rate and volume of air passing over the sampling tube was controlled with a low flow pump (SKC Model-222, SKC, Inc. Eighty-Four, PA). This sample volume was variable but kept well below the typical breakthrough volumes for terpenes on this sampling tube (Anon., 1986).

Foliar chemistry: After the emissions samples were collected, we separated the branchlet and needles from the main branch. Total needle biomass was measured on fresh needles. We then separated the total needle biomass into two parts, half of which we placed in a 60 °C drying oven and weighed daily until no further change in weight was observed. These dried needles were then stored for nitrogen analysis. The remaining needles were ground in liquid nitrogen and stored in 20-mL scintillation vials filled with pentane until they were analyzed for monoterpene concentrations. The pentane storage was never less than 7 days and was more than sufficient to allow for complete solvent extraction of the monoterpenes (Lerdau et al., 1995). The fresh weight/dry weight ratio from the needles used in the nitrogen analyses was applied to each monoterpene sample to provide an estimated dry weight for the sample. All analyses are reported on a dry-weight basis.

Analysis

Hydrocarbon emissions: Samples were analyzed by thermal desorption followed by gas chromatography/mass spectrometry (GC/MS) using a modified form of the EPA TO-1 method (Anon., 1984). A Tekmar AeroTRAP unit (Cincinnati, OH), Tekmar Cryofocusing unit (Cincinnati, OH), and ultrahigh purity helium purge gas were used to thermally desorb hydrocarbons off the cartridges via a multistep process. Cartridges were heated to 220 °C to desorb the sample onto an internal glass-bead-packed trap cooled with liquid nitrogen to -165 °C. Next, the sample was desorbed off the internal trap at 220 °C, passed through a moisture control system to remove water, and refocused onto the head of the column, which was held at -165 °C using liquid nitrogen. Finally, the sample was injected onto the column by flash heating the head of the column to 220 °C. A Finnigan model ITS40 gas chromatograph/ion trap mass spectrometer/data system (San Jose, CA) was used to analyze the hydrocarbons in the samples. A 25-m, 0.25-mm ID DB-5ms column from J&W Scientific (Folsom, CA) was used to separate the terpenes. The temperature of the column was programmed to separate the terpenes of interest. This entailed holding the column at 40 °C for 5 minutes, increasing the temperature at 8 °C/min to 220 °C, and then holding the temperature at 220 °C for 4 minutes. The transfer line to the ion trap mass spectrometer was held at 250 °C, and the ion trap manifold was set to 100 °C. The ion trap mass spectrometer was run through a daily auto-tune sequence prior to data acquisition on samples, standards, and blanks. This auto-tune sequence involved calibrating the mass scale and setting emission current, multiplier voltage, automatic gain control target value to proper values. Mass spectra were acquired under electron ionization (EI) conditions using a scan range of m/z 50 to 200 and a scan rate of 1 scan/second. Terpenes were identified using both retention time confirmation and matching experimental mass spectra against a custom library of mass spectra derived from a series of terpene standards. Terpenes were quantified against external standards, in which the most intense ion for the individual terpene (quantitation ion) was compared to the same ion from analyses of known amounts of neat terpene standards in hexane. Method blanks were used to correct for any response for terpenes on the conditioned cartridges. All emission rates are reported on a dry weight basis.

Foliar chemistry: Monoterpenes were separated on an HP 5890 Series II gas chromatograph equipped with a split/splitless injector, flame ionization detector (FID) and a 30-m DB-1 capillary column (0.32 mm i.d., 1 µm film thickness, J & W Scientific, Folsom CA), 2 mL of sample was injected in the split mode (80:1 split) using a HP 7673 Auto Sampler, He as the carrier gas at a flow rate of 2.2 mL min-1. Column temperature was programmed to stay at 50 °C for 5 minutes, then increase 6 °C/min to 250 °C and held for 5 minutes. Detector temperature was 300 °C and injector temperature was 275 °C. Individual monoterpenes were identified by comparison of their retention times with authentic monoterpene standards (purchased from Sigma/Aldrich Chemical CO, St. Louis, MO) that were analyzed under conditions identical to those used for the unknown samples. Monoterpenes were quantified using fenchone as an internal standard. Fenchone was added to the extract 24 hours prior to analysis. The results are expressed as mg terpene per gram of needle dry weight. Needle nitrogen concentration was measured as total Kjeldahl nitrogen (TKN; calculated as a percentage of needle dry mass) using the digestion and measurement protocol described by Jaeger and Monson (1992). Needles were ground and digested in sulfuric acid with a copper sulfate catalyst at 360 °C for 3 hours and then analyzed colorometrically using a flow injection analyzer (LACHAT Inst., Mequon, WI).

4. Equipment

4.1 Sensor/Instrument Description

None given.

4.1.1 Collection Environment

Samples were collected under ambient environmental conditions.

4.1.2 Source/Platform

Trees.

4.1.3 Source/Platform Mission Objectives

The purpose of the trees and branches for this experiment was to support the measurement equipment.

4.1.4 Key Variables

Monoterpene concentration and monoterpene emission.

4.1.5 Principles of Operation

None given.

4.1.6 Sensor/Instrument Measurement Geometry

None given.

4.1.7 Manufacturer of Sensor/Instrument

Campbell Scientific

AADCO Instruments
Silver Springs, FL

Supelco
Bellafonte, PA

Tekmar
Cincinnati, OH

SKC, Inc.
Eighty Four, PA

Finnigan
San Jose, CA

J&W Scientific
Folsom, CA

Hewlett Packard

LACHAT Inst.
Mequon, WI

4.2 Calibration

4.2.1 Specifications

Terpenes were identified using both retention time confirmation and matching experimental mass spectra against a custom library of mass spectra derived from a series of terpene standards. Terpenes were quantified against external standards, in which the most intense ion for the individual terpene (quantitation ion) was compared to the same ion from analyses of known amounts of neat terpene standards in hexane. Method blanks were used to correct for any response for terpenes on the conditioned cartridges. Monoterpenes were quantified using fenchone as an internal standard.

4.2.1.1 Tolerance

None given.

4.2.2 Frequency of Calibration

The ion trap mass spectrometer was run through a daily auto-tune sequence prior to data acquisition on samples, standards, and blanks. This auto-tune sequence involved calibrating the mass scale and setting emission current, multiplier voltage, automatic gain control target value to proper values.

4.2.3 Other Calibration Information

None given.

5. Data Acquisition Methods

Samples were collected by enclosing branches in a temperature- and light-controlled cuvette connected to a plant gas exchange system (Campbell MPH 1000, Campbell Scientific, Logan, UT) and flowing hydrocarbon-free air over the needles. Temperature was controlled by use of thermoelectric coolers provided by Campbell Scientific, and light intensity was controlled by mounting a projector bulb at a right angle to the top of the glass-topped cuvette. The light was then reflected off of a cold mirror (45° cold mirror, 15-33233, OCLI, Santa Rosa, CA) mounted at a 45° angle to the cuvette. The mirror transmitted light at wavelengths >720 nm and reflected light of shorter wavelengths. Hydrocarbon-free air was produced by pumping ambient air through a clean-air generator (Aadco 5L, AADCO Instruments, Silver Springs, FL) and adding CO_2 back to the entering air stream. All flows and environmental conditions were monitored by the sensors and mass flow controllers of the Campbell MPH 1000. Hydrocarbon emission samples were collected by diverting a fraction of the air exiting the leaf cuvette through a sampling tube packed with a solid sorbent. Supelco Carbotrap 300 cartridges (Bellafonte , PA) with dimensions of 7-inch length and 1/4-inch outer diameter were used in this work. The sampling tubes were conditioned before each use via a Tekmar Thermo Trap unit (Cincinnati, OH) at 220 °C for a minimum of 4 hours at a flow of approximately 10 mL/min of ultrahigh purity nitrogen. A blank from each set of conditioned cartridges was analyzed to ensure that they had been properly cleaned. The flow rate and volume of air passing over the sampling tube was controlled with a low flow pump (SKC Model-222, SKC, Inc. Eighty Four, PA). This sample volume was variable but kept well below the typical breakthrough volumes for terpenes on this sampling tube (Anon., 1986).

After the emissions samples were collected, we separated the branchlet and needles from the main branch. Total needle biomass was measured on fresh needles. We then separated the total needle biomass into two parts, half of which we placed in a 60 °C drying oven and weighed daily until no further change in weight was observed. These dried needles were then stored for nitrogen analysis. The remaining needles were ground in liquid nitrogen and stored in 20-mL scintillation vials filled with pentane until they were analyzed for monoterpene concentrations. The pentane storage was never less than 7 days and was more than sufficient to allow for complete solvent extraction of the monoterpenes (Lerdau et al., 1995). The fresh weight/dry weight ratio from the needles used in the nitrogen analyses was applied to each monoterpene sample to provide an estimated dry weight for the sample. All analyses are reported on a dry-weight basis.

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 for the sites are:

```
SSA-OBS   53.98717°N, 105.11779°W
SSA-OJP   53.91634°N, 104.69203°W
```

7.1.2 Spatial Coverage Map

None given.

7.1.3 Spatial Resolution

These data are point source measurements taken near the given coordinates.

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

The data were collected from 24-May-1994 to 19-Sep-1994.

7.2.2 Temporal Coverage Map

None given.

7.2.3 Temporal Resolution

Monthly averages of the data were calculated for 24-May-1994 to 19-Sep-1994.

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
MEAN_MONOTERPENE_CONC
MEAN_MONOTERPENE_EMISSION
MEAN_NITROGEN_CONC
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.
MEAN_MONOTERPENE_CONC	The averaged monoterpene concentrations from fully expanded needles over the sampling period.
MEAN_MONOTERPENE_EMISSION	The averaged monoterpene emission from fully expanded needles over the sampling period.
MEAN_NITROGEN_CONC	The mean nitrogen concentration for the sampling period.
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]
MEAN_MONOTERPENE_CONC	[milligrams monoterpene][gram^-1 leaf]
MEAN_MONOTERPENE_EMISSION	[micrograms monoterpene][gram^-1 leaf][hour^-1]
MEAN_NITROGEN_CONC	[milligrams monoterpene][gram^-1 leaf]
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:

Column Name	Data Source
SITE_NAME	[Assigned by BORIS Staff]
SUB_SITE	[Assigned by BORIS Staff]
START_DATE	Investigator
END_DATE	Investigator
MEAN_MONOTERPENE_CONC	Campbell MPH 1000
MEAN_MONOTERPENE_EMISSION	Campbell MPH 1000
MEAN_NITROGEN_CONC	Campbell MPH 1000
CRTFCN_CODE	[Assigned by BORIS Staff]
REVISION_DATE	[Assigned by BORIS Staff]

7.3.5 Data Range

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

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SITE_NAME	SSA-OBS-FLXTR	SSA-OJP-FLXTR	None	None	None	None
SUB_SITE	TGB08-CON01	TGB08-CON01	None	None	None	None
START_DATE	24-MAY-94	24-MAY-94	None	None	None	None
END_DATE	19-SEP-94	19-SEP-94	None	None	None	None
MEAN_MONOTERPENE_CONC	1	27.14	None	None	None	None
MEAN_MONOTERPENE_EMISSION	.09	3.51	None	None	None	Blank
MEAN_NITROGEN_CONC	3.16	12.11	None	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	25-MAR-97	25-MAR-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 records from a sample data file on the CD-ROM.

```
SITE_NAME,SUB_SITE,START_DATE,END_DATE,MEAN_MONOTERPENE_CONC,
MEAN_MONOTERPENE_EMISSION,MEAN_NITROGEN_CONC,CRTFCN_CODE,REVISION_DATE
'SSA-OBS-FLXTR','TGB08-CON01',24-MAY-94,19-SEP-94,5.04,.6,,'CPI',25-MAR-97
'SSA-OBS-FLXTR','TGB08-CON01',24-MAY-94,19-SEP-94,6.08,1.08,,'CPI',25-MAR-97
'SSA-OBS-FLXTR','TGB08-CON01',24-MAY-94,19-SEP-94,4.97,1.7,,'CPI',25-MAR-97
```

8. Data Organization

8.1 Data Granularity

The smallest unit of data tracked by the BOREAS Information System (BORIS) was the average monoterpene concentration for a given site on a given day.

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

9.1.1 Derivation Techniques and Algorithms

None given.

9.2 Data Processing Sequence

9.2.1 Processing Steps

None given.

9.2.2 Processing Changes

None given.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

None given.

9.3.2 Calculated Variables
None.

9.4 Graphs and Plots
None.

10. Errors

10.1 Sources of Error
None given.

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
The 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.

11.4 Other Relevant Information
None.

12. Application of the Data Set

None given.

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 monoterpene concentration 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

Jaeger, C.H. and R.K. Monson. 1992. Adaptive Significance Of Nitrogen Storage In Bistorta-Bistortoides, An Alpine Herb Oecologia 92: (4) 578-585.

Lerdau M., P. Matson, R. Fall, and R. Monson. 1995.Ecological Controls Over Monoterpene Emissions From Douglas-Fir (Pseudotsuga-Menziesii) Ecology 76: (8) 2640-2647.

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

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17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None given.

19. List of Acronyms

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ASCII   - American Standard Code for Information Interchange
BOREAS  - BOReal Ecosystem-Atmosphere Study
BORIS   - BOREAS Information System
CD-ROM  - Compact Disk-Read-Only Memory
DAAC    - Distributed Active Archive Center
EI      - Electron Ionization
EOS     - Earth Observing System
EOSDIS  - EOS Data and Information System
FID     - Flame Ionization Detector
GC/MS   - Gas Chromatograph/Mass Spectrometer
GIS     - Geographic Information System
GSFC    - Goddard Space Flight Center
HTML    - Hyper-Text Markup Language
NAD83   - North American Datum of 1983
NASA    - National Aeronautics and Space Administration
NMHC    - Nonmethane Hydrocarbon
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
SSA     - Southern Study Area
TF      - Tower Flux
TGB     - Trace Gas Biogeochemistry
TKN     - Total Kjeldahl Nitrogen
URL     - Uniform Resource Locator
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13. ABSTRACT *(Maximum 200 words)*

The BOREAS TGB-8 team collected data to investigate the controls over NMHC fluxes from boreal forest tree species. This data set contains measurements of monoterpene concentrations in collected foliar gas emissions and foliar samples. The data were collected at the OJP and OBS tower flux sites in the SSA and were the locus for the monoterpene emission measurements. These areas contained mature stands of jack pine and black spruce and were the focal sites in the BOREAS program for studies of biosphere/atmosphere exchange from these two habitat types. The OBS site is situated in a black spruce/sphagnum bog with the largest trees 155 years old and 10-15 m tall. The OJP site is in a jack pine forest, 80 to 120 years old, which lies on a sandy bench of glacial outwash with the largest tree standing 15 m tall. Temporally, the data cover the period of 24-May-1994 to 19-Sep-1994. The data are stored in tabular ASCII files.

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