

NASA/TM—2000–209891, Vol. 143



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

Forrest G. Hall and Shelaine Curd, Editors

Volume 143

**BOREAS TE-6 1994 Soil and
Air Temperatures in the NSA**

J. Norman and T. Wilson

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

October 2000

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BOREAS TE-6 1994 Soil and Air Temperatures in the NSA

John M. Norman, Tim Wilson

Summary

The BOREAS TE-6 team collected several data sets to examine the influence of vegetation, climate, and their interactions on the major carbon fluxes for boreal forest species. This data set contains measurements of the air temperature at a single height and soil temperature at several depths in the NSA from 25-May to 08-Oct-1994. Chromel-Constantan thermocouple wires run by a miniprogrammable data logger (Model 21X, Campbell Scientific, Inc., Logan, UT) provided direct measurements of temperature. The data are stored in tabular ASCII files.

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1. Data Set Overview

1.1 Data Set Identification

BOREAS TE-06 1994 Soil and Air Temperatures in the NSA

1.2 Data Set Introduction

Air and soil temperature data were collected in 1994 at the BOREal Ecosystem-Atmosphere Study (BOREAS) Northern Study Area (NSA) Old Aspen (OA) site. Thirty-minute measurements of soil and mean air temperature were taken below the forest canopy to understand the soil-plant-atmosphere weather conditions for modeling the forest carbon budget.

1.3 Objective/Purpose

The main objective was to measure soil and mean air mean temperature beneath a boreal forest canopy to understand the soil-plant-atmosphere weather conditions for modeling the forest carbon budget.

The temperature within the canopy and the soil relates directly to radiation transport in the canopy and heat movement in the soil. Temperature measurements are important to understand the energy transport in the soil-plant environment. The air and soil temperatures reported here are useful not only as inputs for detailed soil-plant models for energy and mass balances at the soil and canopy surfaces but also for evaluating model predictions of temperature.

1.4 Summary of Parameters

Soil temperature and air temperature.

1.5 Discussion

The mean soil and air temperature within the boreal forest was monitored from 25-May to 08-Oct-1994. In the soil, 23" gauge Chromel-Constantan thermocouples measured temperature at depths of 2, 5, 10, 20, 30, and 50 cm. Above the ground, a 3-mil Chromel-Constantan thermocouple wire, covered with a thin aluminum shield to prevent heating by direct radiation, measured the air temperature at 200 cm above the ground on the north side of a tall tree. A battery-powered miniprogrammable data logger (Model 21X, Campbell Scientific, Inc., Logan, UT) was used to record, process, and store 30-minute averages. Temperature values are expressed in degrees Celsius.

1.6 Related Data Sets

BOREAS AES READAC Surface Meteorological Data

BOREAS AES MARSII Surface Meteorological Data

BOREAS AFM-07 SRC Surface Meteorological Data

2. Investigator(s)

2.1 Investigator(s) Name and Title

John M. Norman
Department of Science
University of Wisconsin-Madison

2.2 Title of Investigation

Measurement and Scaling of Carbon Budgets for Contrasting Boreal Forest Sites

2.3 Contact Information

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Raytheon ITSS
Code 923
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Greenbelt, MD 20771
(301) 286-2447
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3. Theory of Measurements

None given.

4. Equipment

4.1 Sensor/Instrument Description

Chromel-Constantan thermocouple junctions potted in epoxy were used to measure temperature, and a battery-powered, miniprogrammable data logger (21X Model, Campbell Scientific, Inc., Logan, UT) recorded and stored the data.

4.1.1 Collection Environment

The measurement site was located in the northeast corner of Terrestrial Ecology (TE)-06 team's allometry plot 1 under the supervision of Tom Gower, University of Wisconsin-Madison. The thermocouples were permanently placed at 5, 10, 20, 30, and 50 cm. All measurements were taken in a single vertical column, one above the other. The thermocouples were buried in the soil permanently except for the thermocouple measuring the air temperature at 2 m above the ground, which was shielded from the sun.

4.1.2 Source/Platform

The thermocouples were permanently buried in the ground, and each sensor was protected from the soil environment with RTV potting compound. The data logger was housed in a weatherproof shelter and placed on the ground several meters away from where the thermocouples were installed in the ground.

4.1.3 Source/Platform Mission Objectives

The objective was to measure temperature changes at the NSA OA site.

4.1.4 Key Variables

Temperature of soil at 2, 5, 10, 20, 30, and 50 cm. Air temperature at 200 cm height.

4.1.5 Principles of Operation

None given.

4.1.6 Sensor/Instrument Measurement Geometry

The thermocouples were installed in the forest floor in a representative location where sometimes the surface of the ground was in a sunfleck and sometimes it was in the shade of a tree crown. The understory around the location was present but sparse. TE-06 attempted to find a location that was representative of the forest floor.

4.1.7 Manufacturer of Sensor/Instrument

The miniprogrammable data logger (21X) was manufactured by Campbell Scientific, Inc., Logan, UT; the thermocouples were prepared in the lab at the Department of Science, University of Wisconsin-Madison.

4.2 Calibration

All thermocouples were calibrated to an accuracy of 0.5 °C.

4.2.1 Specifications

There were no known factors that may have affected calibration, nor operations of analysis of the data collected.

4.2.1.1 Tolerance

Reasonable temperatures should vary from -10 °C to 50 °C, but the measurement device will measure over a much wider range.

4.2.2 Frequency of Calibration

Once before installation.

4.2.3 Other Calibration Information

None.

5. Data Acquisition Methods

Data are continuous point measurements of temperature from 25-May to 08-Oct-1994. The data were downloaded at irregular intervals; weekly during Intensive Field Campaigns (IFCs), and between IFCs the data were stored in the datalogger until the next IFC.

6. Observations

6.1 Data Notes

None given.

6.2 Field Notes

Data consist of continuous temperature measurements from 25-May to 08-Oct-1994.

7. Data Description

7.1 Spatial Characteristics

Not applicable.

7.1.1 Spatial Coverage

The North American Datum of 1983 (NAD83) coordinates of the NSA aspen site are:

SITE	LATITUDE	LONGITUDE
-----	-----	-----
NSA-OA	55.88691° N	98.67479° W

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

Only one profile of sensors was used; it would be reasonable to say that all the measurements were taken within 1 m².

7.1.4 Projection

Not applicable.

7.1.5 Grid Description

Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

The temperature measurements reported here consist of 30-minute averages calculated from 1-minute data measured from 25-May to 08-Oct-1994.

7.2.2 Temporal Coverage Map

Not applicable.

7.2.3 Temporal Resolution

Data were sampled every minute and averaged over 30 minutes.

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
VOLTAGE
SOIL_TEMP_2CM
SOIL_TEMP_5CM
SOIL_TEMP_10CM
SOIL_TEMP_20CM
SOIL_TEMP_30CM
SOIL_TEMP_50CM
AIR_TEMP_2M
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.
VOLTAGE	The measured battery voltage.
SOIL_TEMP_2CM	Soil temperature at 2 cm depth.
SOIL_TEMP_5CM	Soil temperature at 5 cm depth.
SOIL_TEMP_10CM	Soil temperature at 10 cm depth.
SOIL_TEMP_20CM	Soil temperature at 20 cm depth.
SOIL_TEMP_30CM	Soil temperature measured at 30 cm depth.
SOIL_TEMP_50CM	Soil temperature measured at 50 cm depth.
AIR_TEMP_2M	The air temperature at 2 meters above the ground.
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]
VOLTAGE	[volts]
SOIL_TEMP_2CM	[degrees Celsius]
SOIL_TEMP_5CM	[degrees Celsius]
SOIL_TEMP_10CM	[degrees Celsius]
SOIL_TEMP_20CM	[degrees Celsius]
SOIL_TEMP_30CM	[degrees Celsius]
SOIL_TEMP_50CM	[degrees Celsius]
AIR_TEMP_2M	[degrees Celsius]
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	[Data Logger]
TIME_OBS	[Data Logger]
VOLTAGE	[Data Logger]
SOIL_TEMP_2CM	[Thermometer]
SOIL_TEMP_5CM	[Thermometer]
SOIL_TEMP_10CM	[Thermometer]
SOIL_TEMP_20CM	[Thermometer]
SOIL_TEMP_30CM	[Thermometer]
SOIL_TEMP_50CM	[Thermometer]
AIR_TEMP_2M	[Thermometer]
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-90A-9TETR	NSA-90A-9TETR	None	None	None	None
SUB_SITE	9TE06-TMP01	9TE06-TMP01	None	None	None	None
DATE_OBS	25-MAY-94	08-OCT-94	None	None	None	None
TIME_OBS	0	2330	None	None	None	None
VOLTAGE	11.17	12.5	None	None	None	None
SOIL_TEMP_2CM	.92	19.32	None	None	None	None
SOIL_TEMP_5CM	.91	15.15	None	None	None	None
SOIL_TEMP_10CM	.67	13.72	None	None	None	None
SOIL_TEMP_20CM	.12	11.79	None	None	None	None
SOIL_TEMP_30CM	-.07	10.27	None	None	None	None
SOIL_TEMP_50CM	-.31	9.27	None	None	None	None
AIR_TEMP_2M	-4.174	31.66	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	23-APR-98	23-APR-98	None	None	None	None

Minimum Data Value -- The minimum value found in the column.

Maximum Data Value -- The maximum value found in the column.

Missng Data Value -- The value that indicates missing data. This is used to indicate that an attempt was made to determine the parameter value, but the attempt was unsuccessful.

Unrel Data Value -- The value that indicates unreliable data. This is used to indicate an attempt was made to determine the parameter value, but the value was deemed to be unreliable by the analysis personnel.

Below Detect Limit -- The value that indicates parameter values below the instruments detection limits. This is used to indicate that an attempt was made to determine the parameter value, but the analysis personnel determined that the parameter value was below the detection limit of the instrumentation.

Data Not Cllctd -- This value indicates that no attempt was made to determine the parameter value. This usually indicates that BORIS combined several similar but not identical data sets into the same data base table but this particular science team did not measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.

N/A -- Indicates that the value is not applicable to the respective column.

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

7.4 Sample Data Record

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

```
SITE_NAME,SUB_SITE,DATE_OBS,TIME_OBS,VOLTAGE,SOIL_TEMP_2CM,SOIL_TEMP_5CM,  
SOIL_TEMP_10CM,SOIL_TEMP_20CM,SOIL_TEMP_30CM,SOIL_TEMP_50CM,AIR_TEMP_2M,  
CRTFCN_CODE,REVISION_DATE  
'NSA-9OA-9TETR','9TE06-TMP01',25-MAY-94,0,12.21,4.58,3.05,2.05,.64,.26,.03,8.5,  
'CPI',23-APR-98  
'NSA-9OA-9TETR','9TE06-TMP01',25-MAY-94,30,12.2,4.18,2.89,1.98,.61,.23,0.0,7.76,  
'CPI',23-APR-98
```

8. Data Organization

8.1 Data Granularity

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

8.2 Data Format(s)

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

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

9. Data Manipulations

9.1 Formulae

None.

9.1.1 Derivation Techniques and Algorithms

None.

9.2 Data Processing Sequence

9.2.1 Processing Steps

The data are recorded, processed, and stored online.

9.2.2 Processing changes

None.

9.3 Calculation

The data reported here are raw temperature measurements in degrees Celsius.

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

There were no power failures, and all wires were installed in PVC tubing so nothing could chew on them. There were no known errors.

10.2 Quality Assessment

10.2.1 Data Validation by Source

Temperature data have been collected with great care. The above-ground thermocouple wire is covered with a thin aluminum shield to prevent interference by direct radiation.

10.2.2 Confidence Level/Accuracy Judgment

The temperature data are accurate to 0.5 °C.

10.2.3 Measurement Error for Parameters

Calibration was accomplished to 0.2 °C, but TE-06 suggests a measurement accurate of +/-0.5 °C on the data.

10.2.4 Additional Quality Assessments

None.

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

No known problems.

11.3 Usage of Guidance

None given.

11.4 Other Relevant Information

None given.

12. Application of the Data Set

These data can be used to study temperature variations over time and soil depth.

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 NSA soil and air temperature 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/> [Internet Link].

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 given.

17.2 Journal Articles and Study Reports

Brooks, J.R., L.B. Flanagan, G.T. Varney, and J.R. Ehleringer. 1995. Photosynthesis Profiles in Boreal Forest Canopies: Recycling of Soil-Respired CO₂, Ecological Society of America Annual Meetings, Snowbird, Utah, 1995.

Brooks, J.R., L.B. Flanagan, G.T. Varney, and J.R. Ehleringer. 1997. Vertical gradients in photosynthetic gas exchange characteristics and refixation of respired CO₂ within boreal forest canopies. *Tree Physiol.* 17: 1-12.

Brooks, J.R., L.B. Flanagan, N. Buchmann, and J.R. Ehleringer. 1997. Carbon isotope composition of boreal plants: functional grouping of life forms. *Oecologia*.

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).

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

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

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

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

AFM	- Airborne Fluxes and Meteorology
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
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
NASA	- National Aeronautics and Space Administration
NSA	- Northern Study Area
OA	- Old Aspen
ORNL	- Oak Ridge National Laboratory
PANP	- Prince Albert National Park
SSA	- Southern Study Area
TE	- Terrestrial Ecology
URL	- Uniform Resource Locator

20. Document Information

20.1 Document Revision Date

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20.2 Document Review Date(s)

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20.4 Citation

When using these data, please contact the investigators listed in Section 2.3 and cite any relevant papers in Section 17.2:

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

Norman, J.M., "Measurement and Scaling of Carbon Budgets for Contrasting Boreal Forest Sites." 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.

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20.5 Document Curator

20.6 Document URL

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13. ABSTRACT (Maximum 200 words) The BOREAS TE-6 team collected several data sets to examine the influence of vegetation, climate, and their interactions on the major carbon fluxes for boreal forest species. This data set contains measurements of the air temperature at a single height and soil temperature at several depths in the NSA from 25-May to 08-Oct-1994. Chromel-Constantan thermocouple wires run by a miniprogrammable data logger (Model 21X, Campbell Scientific, Inc., Logan, UT) provided direct measurements of temperature. The data are stored in tabular ASCII files.				
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