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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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
Contact 1:
John M. Norman
Department of Science
University of Wisconsin-Madison
Soils Building, Rm. #263
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Madison, WI 53706
(608) 262-4576
(608) 265-2595 (fax)
norman@calshp.cals.wisc.edu

Contact 2:
Shelaine Curd
Raytheon ITSS
Code 923
NASA GSFC
Greenbelt, MD 20771
(301) 286-2447
shelaine.curd@gsfc.nasa.gov
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

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:

<table>
<thead>
<tr>
<th>SITE</th>
<th>LATITUDE</th>
<th>LONGITUDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSA-OA</td>
<td>55.88691° N</td>
<td>98.67479° W</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Column Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
</tr>
<tr>
<td>SUB_SITE</td>
</tr>
<tr>
<td>DATE_OBS</td>
</tr>
<tr>
<td>TIME_OBS</td>
</tr>
<tr>
<td>VOLTAGE</td>
</tr>
<tr>
<td>SOIL_TEMP_2CM</td>
</tr>
<tr>
<td>SOIL_TEMP_5CM</td>
</tr>
<tr>
<td>SOIL_TEMP_10CM</td>
</tr>
<tr>
<td>SOIL_TEMP_20CM</td>
</tr>
<tr>
<td>SOIL_TEMP_30CM</td>
</tr>
<tr>
<td>SOIL_TEMP_50CM</td>
</tr>
<tr>
<td>AIR_TEMP_2M</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
</tr>
<tr>
<td>REVISION_DATE</td>
</tr>
</tbody>
</table>

7.3.2 Variable Description/Definition
The descriptions of the parameters contained in the data files on the CD-ROM are:

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>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.</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>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.</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>The date on which the data were collected.</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>The Greenwich Mean Time (GMT) when the data were</td>
</tr>
</tbody>
</table>
The measured battery voltage.
The soil temperature at 2 cm depth.
The soil temperature at 5 cm depth.
The soil temperature at 10 cm depth.
The soil temperature at 20 cm depth.
The soil temperature measured at 30 cm depth.
The soil temperature measured at 50 cm depth.
The air temperature at 2 meters above the ground.
The BOREAS certification level of the data.
Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
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:

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>[none]</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>[none]</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>[DD-MON-YY]</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>[HHMM GMT]</td>
</tr>
<tr>
<td>VOLTAGE</td>
<td>[volts]</td>
</tr>
<tr>
<td>SOIL_TEMP_2CM</td>
<td>[degrees Celsius]</td>
</tr>
<tr>
<td>SOIL_TEMP_5CM</td>
<td>[degrees Celsius]</td>
</tr>
<tr>
<td>SOIL_TEMP_10CM</td>
<td>[degrees Celsius]</td>
</tr>
<tr>
<td>SOIL_TEMP_20CM</td>
<td>[degrees Celsius]</td>
</tr>
<tr>
<td>SOIL_TEMP_30CM</td>
<td>[degrees Celsius]</td>
</tr>
<tr>
<td>SOIL_TEMP_50CM</td>
<td>[degrees Celsius]</td>
</tr>
<tr>
<td>AIR_TEMP_2M</td>
<td>[degrees Celsius]</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td>[none]</td>
</tr>
<tr>
<td>REVISION_DATE</td>
<td>[DD-MON-YY]</td>
</tr>
</tbody>
</table>

**7.3.4 Data Source**

The sources of the parameter values contained in the data files on the CD-ROM are:

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>[BORIS Designation]</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>[BORIS Designation]</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>[Data Logger]</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>[Data Logger]</td>
</tr>
<tr>
<td>VOLTAGE</td>
<td>[Data Logger]</td>
</tr>
<tr>
<td>SOIL_TEMP_2CM</td>
<td>[Thermometer]</td>
</tr>
<tr>
<td>SOIL_TEMP_5CM</td>
<td>[Thermometer]</td>
</tr>
<tr>
<td>SOIL_TEMP_10CM</td>
<td>[Thermometer]</td>
</tr>
<tr>
<td>SOIL_TEMP_20CM</td>
<td>[Thermometer]</td>
</tr>
<tr>
<td>SOIL_TEMP_30CM</td>
<td>[Thermometer]</td>
</tr>
<tr>
<td>SOIL_TEMP_50CM</td>
<td>[Thermometer]</td>
</tr>
<tr>
<td>AIR_TEMP_2M</td>
<td>[Thermometer]</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td>[BORIS Designation]</td>
</tr>
<tr>
<td>REVISION_DATE</td>
<td>[BORIS Designation]</td>
</tr>
</tbody>
</table>
### 7.3.5 Data Range

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

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Minimum Data Value</th>
<th>Maximum Data Value</th>
<th>Missing Data Value</th>
<th>Unrel Data Value</th>
<th>Below Detect Limit</th>
<th>Data Not Collctd</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>NSA-9OA-9TETR</td>
<td>NSA-9OA-9TETR</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>9TE06-TEMP01</td>
<td>9TE06-TEMP01</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>25-MAY-94</td>
<td>08-OCT-94</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>0</td>
<td>2330</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>VOLTAGE</td>
<td>11.17</td>
<td>12.5</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SOIL_TEMP_2CM</td>
<td>.92</td>
<td>19.32</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SOIL_TEMP_5CM</td>
<td>.91</td>
<td>15.15</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SOIL_TEMP_10CM</td>
<td>.67</td>
<td>13.72</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SOIL_TEMP_20CM</td>
<td>.12</td>
<td>11.79</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SOIL_TEMP_30CM</td>
<td>-.07</td>
<td>10.27</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SOIL_TEMP_50CM</td>
<td>-.31</td>
<td>9.27</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>AIR_TEMP_2M</td>
<td>-4.174</td>
<td>31.66</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td>CPI</td>
<td>CPI</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>REVISION_DATE</td>
<td>23-APR-98</td>
<td>23-APR-98</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

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

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

**Missing 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 Collctd** --- 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 Addition 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


17.3 Archive/DBMS Usage Documentation
None.

18. Glossary of Terms

None.

19. List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFM</td>
<td>Airborne Fluxes and Meteorology</td>
</tr>
<tr>
<td>ASCII</td>
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<td>BOReal Ecosystem-Atmosphere Study</td>
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<td>BORIS</td>
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<tr>
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<td>URL</td>
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**Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)**

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

**John Norman and Tim Wilson**

**Forrest G. Hall and Shelaine Curd, Editors**

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.

**ABSTRACT (Maximum 200 words)**

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