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

Forrest G. Hall and Andrea Papagno, Editors

Volume 165

BOREAS TE-11 Sap Flow Data

B. Saugier

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

October 2000

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BOREAS TE-11 Sap Flow Data

Bernard Saugier

Summary

The BOREAS TE-11 team collected several data sets in support of its efforts to characterize and interpret information on the sap flow, gas exchange, and lichen photosynthesis of boreal vegetation and meteorological data of the area studied. This data set contains measurements of sap flow conducted at the SSA-OJP site in the growing seasons of 1993 and 1994. The data are stored in ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS TE-11 Sap Flow Data

1.2 Data Set Introduction

The Terrestrial Ecology (TE)-11 team took measurements of sap flow at the BOReal Ecosystem-Atmosphere Study (BOREAS) Southern Study Area (SSA) Old Jack Pine (OJP) site during the growing seasons of 1993 and 1994 using hand-made probes.

1.3 Objective/Purpose

The purposes of the work were to:

- Measure the average sap flow velocity in six trees.
- Calculate the sap flow from the velocity and the sapwood area.

1.4 Summary of Parameters

Sap flow measurements were taken at the SSA-OJP site on Julian days 236 to 245 in 1993 and Julian days 118 to 259 in 1994. Stand transpiration is computed in mm/hour for each of the measured trees. Sapwood area on TE-11's site was taken as 12.3 m^2/ha. This figure may change according to new biometric data.

1.5 Discussion

The TE-11 team's aim is to compare these data with a micrometeorological (micromet) estimate of tree transpiration (H_2O flux above the forest minus H_2O flux above the soil). If the comparison is good, these data will be used to fill out gaps that occurred when the micromet measurements were not operating.

1.6 Related Data Sets

BOREAS TE-11 Leaf Gas Exchange Measurements

2. Investigator(s)

2.1 Investigator(s) Name and Title

Bernard Saugier
Professor

2.2 Title of Investigation

Seasonal Variations of Net Photosynthesis and Transpiration at the Tree Level

2.3 Contact Information

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3. Theory of Measurements

Two cylindrical probes were inserted perpendicular to the tree trunk; one was continuously heated, while the other was not. Each probe contained a copper-constantan junction. The two constantan wires were connected together, and the voltage between the two copper wires was measured proportional to the temperature difference between the two probes. It was then transformed into an averaged sap velocity using a formula that was independent of the tree species. Then, sap flow was calculated as the product of sap velocity by the sapwood area.

From these measurements, stand sapwood area was 12.3 m^2/ha for a basal area of 22.5 m^2/ha. The diameter of the probes was 2 mm; the length of the probes was 20 mm (usually). Resistance of the constantan wire was about 10 ohms. The temperature difference between the probes was about 12 °C during the night, and it decreased during the day.

4. Equipment

4.1 Sensor/Instrument Description

The probes were made by Andre Granier, a coinvestigator, who went to the site in 1993 and in April 1994 to install the probes. They were connected to a CR10 data logger, downloaded to a portable PC.

4.1.1 Collection Environment

None given.

4.1.2 Source/Platform

None given.

4.1.3 Source/Platform Mission Objectives

None given.

4.1.4 Key Variables

Sap flow velocity, temperature difference, resistance, sap flow area.

4.1.5 Principles of Operation

Two cylindrical probes were inserted perpendicular to the tree trunk; one was continuously heated, while the other was not. Each probe contained a copper-constantan junction. The two constantan wires were connected together, and the voltage between the two copper wires was measured proportional to the temperature difference between the two probes. It was then transformed into an averaged sap velocity using a formula that was independent of the tree species. Finally, sap flow was calculated as the product of sap velocity by the sapwood area.

4.1.6 Sensor/Instrument Measurement Geometry

None given.

4.1.7 Manufacturer of Sensor/Instrument

CR10 Data Logger
Campbell Scientific, Inc.
815 West 1800 North
Logan, UT 84321-1784
(435) 753-2342
(435) 750-9540 (fax)
support@campbellsci.com

The probes were made by Andre Granier, a coinvestigator.

4.2 Calibration

No calibration was required in principle. The test will be the comparison with the micromet measurements (see above).

4.2.1 Specifications

None given.

4.2.1.1 Tolerance

None given.

4.2.2 Frequency of Calibration

None given.

4.2.3 Other Calibration Information

None given.

5. Data Acquisition Methods

A Campbell Scientific, Inc., CR10 data logger was used for the acquisition and storage of data. Six channels were used in 1994.

6. Observations

6.1 Data Notes

None given.

6.2 Field Notes

The TE-11 team had fun and had no problems with this technique, which worked very well unattended for long periods. The only problem was with sensor 1, as mentioned in Section 10.1.

7. Data Description

7.1 Spatial Characteristics

The six trees were about 20 m away from the TE scaffolding towers, in the direction of the micromet tower. The following table gives, for each tree, its circumference (C) at breast height (h) in mm and its approximate height in m.

Tree Number	Circumference (mm)	Height (m)
1	256	10.50
2	331	11.25
3	362	13.25
4	368	12.75
5	435	13.50
6	521	14.70

7.1.1 Spatial Coverage

At SSA-OJP. The six trees were about 20 m away from the TE scaffolding towers, in the direction of the micromet tower.

The SSA measurement site and its associated North American Datum of 1983 (NAD83) coordinates are:

- OJP, site id G2L3T, Lat/Long: 53.91634° N, 104.69203° W, UTM Zone 13, N: 5974257.5, E: 520227.7.

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

None given.

7.1.4 Projection

None given.

7.1.5 Grid Description

None given.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

Measurements were taken every 15 minutes, from day 236 to day 245, in 1993, and measurements were taken every 30 minutes, from day 118 to day 259, in 1994.

In 1994, the first data were not reliable because the sensors took some time to reach equilibrium and because alternating freezing and thawing gave strange results. In 1994, data were taken from day 120 and may not be very good until day 125.

7.2.2 Temporal Coverage Map

None given.

7.2.3 Temporal Resolution

None given.

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
TREE_ID
SPECIES
SAPFLOW_RATE
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.
TREE_ID	Identifier of the mapped tree or plant stem.
SPECIES	Botanical (Latin) name of the species (Genus species).
SAPFLOW_RATE	The sap flow rate of the sample tree.
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]
TREE_ID	[none]
SPECIES	[none]
SAPFLOW_RATE	[millimeters][hour^-1]
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	[Human Observer]
TIME_OBS	[Human Observer]
TREE_ID	[Human Observer]
SPECIES	[Human Observer]
SAPFLOW_RATE	[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	SSA-OJP-FLXTR	SSA-OJP-FLXTR	None	None	None	None
SUB_SITE	9TE11-SAP01	9TE11-SAP01	None	None	None	None
DATE_OBS	25-AUG-93	16-SEP-94	None	None	None	None
TIME_OBS	0	2345	None	None	None	None
TREE_ID	1	6	None	None	None	None
SPECIES	N/A	N/A	None	None	None	None
SAPFLOW_RATE	0	1.228	-999	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	14-SEP-98	14-SEP-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,TREE_ID,SPECIES,SAPFLOW_RATE,CRTFCN_CODE,
REVISION_DATE
'SSA-OJP-FLXTR','9TE11-SAP01',25-AUG-93,15,1,'Pinus banksiana',.096,'CPI',
14-SEP-98
'SSA-OJP-FLXTR','9TE11-SAP01',25-AUG-93,15,2,'Pinus banksiana',.017,'CPI',
14-SEP-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

The thermocouples gave a voltage representing the temperature difference DT. At present, there is no record of the absolute temperature of the trunk, so a constant factor was assumed for converting voltage to temperature difference: voltage in mV was multiplied by 25 to obtain DT in degrees Celsius. DT was called the actual temperature difference and DTM the maximum temperature difference (for a transpiration assumed to be zero). This was done directly in the program of the data logger.

U, the average sap velocity, is computed as:

$$U = 119*(DTM/DT-1)^{1.23} \text{ in micrometers/second} \qquad (1)$$

F, the sap flow, is computed as:

$$F = U*SA*AK \quad (2)$$

where: SA (sapwood area) is $1.23E^{-3}$ m^2/m^2, m^2 of trunk per m^2 of ground
AK = $3600*1E^{-3}$ transforms micrometers per second into mm/hour

9.2 Data Processing Sequence

The raw data were stored by the data logger. The data were then downloaded on the hard disk of a portable PC in a file named fluxseve.dat. This file was edited with Word for Windows, resulting in a file called fsevexxx.dat. Then a program called fsev94.bas produced an easy-to-read file called ojpstx_94.dat, containing raw data. This file was checked for errors and edited if necessary.

The data were then processed by a program called dtmse294.bas, which computed the maximum nighttime values of DT (DTMAX), where DT is the temperature difference between the sensors. Then another program, dtmm.bas, computed a new set of DTMAX, in the following way. First, the local maxima of DTMAX were calculated, and then the new DTMAX were calculated by linear interpolation between these local maxima, and stored in a file called dtmnx.dat. This procedure has the advantage of not taking into account nights during which a significant transpiration occurs, which leads to decreased (and erroneous) values of DTMAX.

Finally, a program called fsevf394.bas computed sap flows from the raw data in file ojpstx.dat and from the DTMAX in the file called dtmnx.dat. The resultant sap flow files are called sapfx_94.dat (x=1 or 2). The two sap flow files were merged into a single file called sfojp94.dat (standing for Sap Flow of Old Jack Pine in 1994). The data from this final file were sent to BORIS. Raw data and intermediate data are available on request.

9.2.1 Processing Steps

None given.

9.2.2 Processing Changes

None given.

9.3 Calculations

See Section 9.1.1.

9.3.1 Special Corrections/Adjustments

None given.

9.3.2 Calculated Variables

None given.

9.4 Graphs and Plots

QuattroPro for Windows was used to produce graphs. There is not an easy way to make them accessible (other than by giving the cumbersome QP files). Graphs produced were:

- Diurnal values of sap flow and potential evaporation (computed from the metstation data and standard Penman formula).
- The ratio of diurnal values of sap flow and potential evaporation, which increased from 0.1 in the beginning of May to a maximum of 0.3 in July and decreased to below 0.2 in mid-September.

10. Errors

10.1 Sources of Error

One possible source is the accuracy in the measurement of the voltage, 250 to 500 microvolts. This did not seem to be a problem with the Campbell data logger. The second source is the assumption of a zero transpiration at night, necessary to get the maximum temperature difference DTM, and the drift of DTM with time. The above-described procedure should make the best use of the data.

Another source of error may come from the sample of the six trees. These may not be representative of the tree stand. A comparison between an inventory made at TE-11's site in 1993 on only 100 trees and an inventory by Bob Knox on a larger sample (50 m * 50 m) shows that TE-11's sample is relatively representative.

Also, the value taken for the sapwood area (12.3 m^2/ha) needs independent verification.

TE-11 believes these data are fine when using daily values. The half-hourly values are also good, but there is a time lag between the values of branch transpiration (measured with branch bags) and sap flow values. This time lag is about 1 hour (maybe 1 hour and 15 minutes). Sap flow lags behind transpiration, so when using half-hourly values, subtract 1 hour from the time.

The sensor (1) installed on the smallest tree did not work all the time, and TE-11 did not use the data.

In 1994, the first data were not reliable because the sensors took some time to reach equilibrium. The alternating freezing and thawing conditions gave strange results. In 1994, data were given from day 120, but may not be very good until day 125.

10.2 Quality Assessment

A comparison will be done between the stand transpiration calculated by sap flow, and the difference between the latent heat fluxes above and below the forest canopy, as given by Dennis Baldocchi (100 W/m^2 = 0.15 mm/h). A preliminary comparison showed roughly the same values in 1994 as in 1993.

The data file was checked for errors and edited as necessary.

10.2.1 Data Validation by Source

None given.

10.2.2 Confidence Level/Accuracy Judgment

None given.

10.2.3 Measurement Error for Parameters

None given.

10.2.4 Additional Quality Assessments

None given.

10.2.5 Data Verification by Data Center

Data were examined for general consistency and clarity.

11. Notes

11.1 Limitations of the Data

None given.

11.2 Known Problems with the Data

Only 2-cm sensors were used in 1994. It should be remembered that sap flow was measured at breast height, and this follows transpiration with a delay that is dependent on the variation in the amount of water stored by the trees. So although TE-11 believes that the maximum values and the diurnal values are good, the instantaneous values should be used with care. A delay of about 1 hour between transpiration and sap flow variations was common (see above).

11.3 Usage Guidance

See Sections 10.1 and 11.1.

11.4 Other Relevant Information

The interpretation of the data requires knowledge of the variables affecting the evaporative demand: net radiation, saturation deficit, wind speed, and air temperature. These data are given in 1993 and 1994 by the mesomet station in Prince Albert (PA)-OJP.

12. Application of the Data Set

These data can be used to obtain the sap flow rates for OJP in the SSA.

13. Future Modifications and Plans

None given.

14. Software

14.1 Software Description

Word for Windows and QuattroPro were used.

14.2 Software Access

None given.

15. Data Access

The TE-11 sap flow 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 Satellite/Instrument/Data Processing Documentation

None given.

17.2 Journal Articles and Study Reports

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.

Saugier B., A. Granier, J.Y. Pontailler, E. Dufrêne, and D.D. Baldocchi. 1997. Transpiration of a boreal pine forest measured by branch bags, sap flow and micrometeorological methods. Tree Physiology, 17, 511-519.

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

```
DT  - The actual temperature difference between the probes.
DTM - The maximum temperature difference between the probes.
```

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
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
NAD83   - North American Datum of 1983
NASA    - National Aeronautics and Space Administration
NOAA    - National Oceanic and Atmospheric Administration
NSA     - Northern Study Area
OJP     - Old Jack Pine
ORNL    - Oak Ridge National Laboratory
PA      - Prince Albert
PANP    - Prince Albert National Park
SSA     - Southern Study Area
TE      - Terrestrial Ecology
URL     - Uniform Resource Locator
UTM     - Universal Transverse Mercator
```

20. Document Information

20.1 Document Revision Date

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20.2 Document Review Date(s)

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When using these data, please contact B. Saugier (see Section 2.3) as well as citing relevant papers in Section 17.2.

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

Saugier, B., "Seasonal Variations of Net Photosynthesis and Transpiration at the Tree Level." 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:

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The BOREAS TE-11 team collected several data sets in support of its efforts to characterize and interpret information on the sap flow, gas exchange, and lichen photosynthesis of boreal vegetation and meteorological data of the area studied. This data set contains measurements of sap flow conducted at the SSA-OJP site in the growing seasons of 1993 and 1994. The data are stored in ASCII files.

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