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

*Forrest G. Hall and Sara K. Conrad, Editors*

### **Volume 221**

## **BOREAS TGB-1 NSA SF<sub>6</sub> Chamber Flux Data**

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November 2000

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# **BOREAS TGB-1 NSA SF<sub>6</sub> Chamber Flux Data**

Patrick M. Crill, Ruth K. Varner

## **Summary**

The BOREAS TGB-1 team made several chamber and tower measurements of trace gases at sites in the BOREAS NSA. This data set contains sulfur hexafluoride (SF<sub>6</sub>) dark chamber flux measurements at the NSA-OJP and NSA-YJP sites from 16-May through 13-Sep-1994. Gas samples were extracted approximately every 7 days from dark chambers and analyzed at the NSA lab facility. The data are provided in tabular ASCII files.

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## **1. Data Set Overview**

### **1.1 Data Set Identification**

BOREAS TGB-01 NSA SF<sub>6</sub> Chamber Flux Data

### **1.2 Data Set Introduction**

Chamber flux measurements were taken at the BOREal Ecosystem Atmosphere Study (BOREAS) Northern Study Area (NSA) Old Jack Pine (OJP) and Young Jack Pine (YJP) sites during the summer of 1994. The purpose of these measurements was to examine the trace gas exchange between the atmosphere and the boreal soils. The following is a description of the acquisition of data and the final data sets.

### **1.3 Objective/Purpose**

Chamber fluxes were measured at the OJP and YJP sites in the NSA to determine the soil surface exchange rates of SF<sub>6</sub>.

## **1.4 Summary of Parameters**

SF<sub>6</sub> chamber fluxes were measured at the NSA OJP and YJP sites. Temperatures of the chamber, 1-cm soil depth, and 10-cm soil depth were recorded at the OJP and YJP sites.

## **1.5 Discussion**

The chamber flux data included in SF6\_flux.txt includes the SF<sub>6</sub> tracer study that was completed at the OJP and YJP aluminum chamber and collar sites.

## **1.6 Related Data Sets**

BOREAS TGB-01 Soil CH<sub>4</sub> and CO<sub>2</sub> Profile Data from NSA Tower Sites  
BOREAS TGB-01 NSA CH<sub>4</sub> and CO<sub>2</sub> Chamber Flux Data  
BOREAS TGB-01 CH<sub>4</sub> Concentration and Flux Data from NSA Tower Sites  
BOREAS TGB-03 CH<sub>4</sub> and CO<sub>2</sub> Chamber Flux Data over NSA Upland Sites  
BOREAS TGB-03 Dissolved Organic Carbon Data from the NSA

# **2. Investigator(s)**

## **2.1 Investigator(s) Name and Title**

Dr. Patrick M. Crill  
Research Associate Professor  
University of New Hampshire

## **2.2 Title of Investigation**

Magnitude and Control of Trace Gas Exchange in Boreal Ecosystems

## **2.3 Contact Information**

### **Contact 1:**

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Jeffrey.Newcomer@gsfc.nasa.gov

### **3. Theory of Measurements**

None given.

### **4. Equipment**

#### **4.1 Sensor/Instrument Description**

SF<sub>6</sub> was quantified using a Shimadzu GC-8A Gas Chromatograph (GC) equipped with an electron capture detector (ECD). The oven temperature during sample analysis was run at 130 °C and the detector at 300 °C. Ultra-high-purity 5% CH<sub>4</sub>/95% Argon carrier gas was used at a flow rate through the columns of 30 mL/min. Analog signals (0-1 V) from the detectors were digitized at 10 Hz with a Hewlett Packard (HP) 35000D A/D board and quantified and logged using HP ChemStation software. Chamber fluxes were accomplished with aluminum chambers manufactured at the University of New Hampshire and designed by Patrick Crill.

##### **4.1.1 Collection Environment**

The chamber fluxes were collected under ambient conditions. The GC analysis was completed at the Hayes Road Lab in Thompson, Manitoba.

##### **4.1.2 Source/Platform**

Ground.

##### **4.1.3 Source/Platform Mission Objectives**

The mission objective was to determine the diffusion rate of SF<sub>6</sub> at OJP and YJP.

##### **4.1.4 Key Variables**

The key variables measured during the fluxes were SF<sub>6</sub> diffusion rate and temperature.

#### **4.1.5 Principles of Operation**

SF<sub>6</sub> was quantified using a Shimadzu GC8A equipped with an ECD. When the carrier gas, CH<sub>4</sub>-Ar, flows into a cell containing <sup>63</sup>Ni, it is ionized by the radiation from this radioisotope. When a pulsed voltage is applied across the cell electrodes, an ion current flows.

When the carrier gas brings a sample into contact with the cell, the electron affinitive compounds in the sample capture the free electrons and become negative ions. These negative ions combine with positive ions in the flow and subsequently decrease the ion concentration and therefore the current. This change is measured by the detector and compared to a reference current, pure carrier gas (Instruction Manual: GC-8A, Shimadzu Corporation, Kyoto, Japan).

#### **4.1.6 Sensor/Instrument Measurement Geometry**

Not applicable.

#### **4.1.7 Manufacturer of Sensor/Instrument**

Manufacturer of GC-14A FID/TCD, GC-MINI2, and GC-8A ECD  
Shimadzu Scientific Instruments, Inc.  
7102 Riverwood Drive  
Columbia, MD 21046  
(410) 381-1227

#### **4.2 Calibration**

Signal peaks from the detectors were quantified with working standards calibrated against Canadian Atmospheric Environment Services (AES) certified primary standards acquired by the BOREAS project. Uncertainty in the standards' analyses on a given day ranged from 0.1 to 0.2%.

##### **4.2.1 Specifications**

Not applicable.

##### **4.2.1.1 Tolerance**

The sensitivity of the ECD is 0.2 pg for gamma BHC.

##### **4.2.2 Frequency of Calibration**

The instrument is calibrated on a daily basis. Standards are run generally before and after samples on a given day of analysis.

##### **4.2.3 Other Calibration Information**

Not applicable.

## **5. Data Acquisition Methods**

The chamber fluxes are determined by analysis of concentration of SF<sub>6</sub> in a time series of grab samples of headspace over the ground surface enclosed by a dark aluminum chamber. At time zero, 5 mL of SF<sub>6</sub> stock was added to the chamber headspace. The stock mixture is 10 µL SF<sub>6</sub> diluted into 60 mL of air so the mixing ratio is approximately 167 ppmv SF<sub>6</sub>. The headspace concentration is equal to about 12 ppbv after the injection of the stock. The volume of the two aluminum chambers was 0.071 and 0.120 m<sup>3</sup> over an area of 0.397 m<sup>2</sup>. The aluminum chamber was placed on the trough of an aluminum collar embedded in the ground. Water was added to the trough of the collar to create an airtight seal. The volume of the plastic chambers was 0.028 m<sup>3</sup> over an area of 0.078 m<sup>2</sup>. The seal between the chamber and collar was made using weather stripping or water as appropriate. Five 60-mL samples were removed from the headspace with polypropylene syringes and polycarbonate/nylon stopcocks at 4-minute intervals for 20 minutes (five samples). Samples were returned to the Hayes Road lab and analyzed for SF<sub>6</sub> using gas chromatography within 12 hours after collection.



## **6. Observations**

### **6.1 Data Notes**

None given.

### **6.2 Field Notes**

None given.

## **7. Data Description**

### **7.1 Spatial Characteristics**

Not applicable.

#### **7.1.1 Spatial Coverage**

The North American Datum of 1983 (NAD83) coordinates of the sites are:

NSA OJP: (55.92842° N, 98.62396° W)

NSA YJP: (55.89575° N, 98.28706° W)

#### **7.1.2 Spatial Coverage Map**

Not applicable.

#### **7.1.3 Spatial Resolution**

These are point source measurements.

#### **7.1.4 Projection**

Not applicable.

#### **7.1.5 Grid Description**

Not applicable.

### **7.2 Temporal Characteristics**

#### **7.2.1 Temporal Coverage**

The chamber fluxes were taken approximately every 7 days from 16-May-1994 through 13-Sep-1994.

#### **7.2.2 Temporal Coverage Map**

Not applicable.

#### **7.2.3 Temporal Resolution**

Not applicable.

### **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  
COLLAR\_ID  
CHAMBER\_TEMP  
SF6\_RATE  
COVER\_TYPE  
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-CCCC, where SSS identifies the portion of the study area: NSA, SSA, REG, or TRN; TTT identifies the cover type for the site (999 if unknown); and CCCC is the identifier for the site (exactly what it means will vary with site type).
SUB_SITE	The identifier assigned to the subsite by BOREAS, in the format GGGGG-IIIII, where GGGGG is the group associated with the subsite instrument (e.g. HYD06 or STAFF), and IIIII is the identifier for the subsite (often this will refer to an instrument).
DATE_OBS	The date on which the data were collected.
COLLAR_ID	A Trace Gas Biogeochemistry (TGB)01 designation for the chamber collar sites, in the form of A-BBB-##, where A = C or M (Crill or Moosavi), BBB denotes the site, and possibly microtopographic designation, and ## is a sequention collar number.
CHAMBER_TEMP	Temperature of the chamber used to determine the SF6 flux.
SF6_RATE	The SF6 diffusion rate (K).
COVER_TYPE	The dominant species, vegetation or type of land cover that exists at the location.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are Checked by PI (CPI), Certified by Group (CGR), Preliminary (PRE), and CPI but but questionable (CPI-???).
REVISION_DATE	The most recent date that 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]
COLLAR_ID	[none]
CHAMBER_TEMP	[degrees Celsius]
SF6_RATE	[minute-1]
COVER_TYPE	[none]
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	Not applicable
SUB_SITE	Not applicable
DATE_OBS	Investigator
COLLAR_ID	Investigator
CHAMBER_TEMP	Thermometer
SF6_RATE	Shimadzu GC8A
COVER_TYPE	Investigator
CRTFCN_CODE	Not applicable
REVISION_DATE	Not applicable

### 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 Cllected
SITE_NAME	NSA-OJP-FLXTR	NSA-YJP-FLXTR	None	None	None	None
SUB_SITE	TGB01-FLX01	TGB01-FLX01	None	None	None	None
DATE_OBS	30-JUL-94	10-SEP-94	None	None	None	None
COLLAR_ID	C-OJP-ua-01	C-YJP-ul-04	None	None	None	None
CHAMBER_TEMP	9.6	27.5	None	None	None	None
SF6_RATE	-0.1589	-0.0034	None	None	None	None
COVER_TYPE	N/A	N/A	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	02-JAN-97	02-JAN-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 that an attempt was made to determine the

parameter value, but the analysis personnel deemed the value to be unreliable.

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 BOREAS Information System (BORIS) staff 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, DATE_OBS, COLLAR_ID, CHAMBER_TEMP, SF6_RATE, COVER_TYPE,
CRTFCN_CODE, REVISION_DATE
'NSA-OJP-FLXTR', 'TGB01-FLX01', 30-JUL-94, 'C-OJP-ul-02', 24.4, -.0163, 'Lichen', 'CPI',
02-JAN-97
'NSA-OJP-FLXTR', 'TGB01-FLX01', 01-SEP-94, 'C-OJP-ul-03', 22, -.067, 'Lichen', 'CPI',
02-JAN-97
'NSA-OJP-FLXTR', 'TGB01-FLX01', 03-SEP-94, 'C-OJP-ul-03', 19, -.0182, 'Lichen', 'CPI',
02-JAN-97
```

## 8. Data Organization

### 8.1 Data Granularity

The smallest unit of data tracked by BORIS is the measurement(s) made 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

$$R_f = C_{std}/A_{std}$$
$$C_s = R_f * A_s$$

Where:  $R_f$  = Response factor

$A_{std}$  = Average of 10 standard peak areas

$C_{std}$  = Concentration of the standard

$C_s$  = Concentration of the sample

$A_s$  = Peak area of sample

SF<sub>6</sub> concentrations were calculated from the average of 10 peak areas of known SF<sub>6</sub> standards. The response factor was calculated as the concentration of the known standard divided by the average of 10 standard peak areas. The peak area of the unknown sample was multiplied by the response factor.

The SF<sub>6</sub> rate (K) value was calculated by fitting a linear regression to the ln (natural logarithm) of the concentrations of SF<sub>6</sub> versus time. The regressions of the time series were expected to have an r<sup>2</sup> of greater than 0.85.

If -888 is present in the data set, it indicates that a measurement was taken but discarded for some reason. If -999 is present, then no data were taken.

#### 9.1.1 Derivation Techniques and Algorithms

The K value measured for SF<sub>6</sub> is used to determine the rate of diffusion of CH<sub>4</sub> and CO<sub>2</sub> to the soil surface. The relationship can be seen from the following equation:

$$DSF_6/((mSF_6)^{1/2}) = Di/((mi)^{1/2}) \quad (\text{Trumbore, 1995, and Rolston, 1991})$$

where:  $DSF_6$  = measured diffusion of SF<sub>6</sub>

$mSF_6$  = molecular weight of SF<sub>6</sub> (146 g/mol)

$Di$  = unknown diffusion of substance i (CH<sub>4</sub> or CO<sub>2</sub>)

$mi$  = molecular weight of substance i (CH<sub>4</sub> = 16 g/mol; CO<sub>2</sub> = 44 g/mol)

From this information, given a known starting concentration of CO<sub>2</sub> and CH<sub>4</sub>, one can calculate the diffusive flux to the surface:

$$Di * dCi/dz = Fd \quad (\text{Trumbore, 1995})$$

Where:  $dCi/dz$  = soil profile of gas i

$Fd$  = diffusive flux

See Rolston (1991) and Trumbore (1995) for more detailed explanation of the methods and theory.

### 9.2 Data Processing Sequence

#### 9.2.1 Processing Steps

None given.

#### 9.2.2 Processing Changes

None.

### **9.3 Calculations**

Not applicable.

#### **9.3.1 Special Corrections/Adjustments**

Not applicable.

#### **9.3.2 Calculated Variables**

Not applicable.

### **9.4 Graphs and Plots**

None.

## **10. Errors**

### **10.1 Sources of Error**

The analytical precision of the GCs is 0.2% for CH<sub>4</sub> and 1% for CO<sub>2</sub>.

### **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**

The analytical precision of the GCs is 0.2% for CH<sub>4</sub> and 1% for CO<sub>2</sub>.

#### **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**

The analytical precision of the GCs is 0.2% for CH<sub>4</sub> and 1% for CO<sub>2</sub>.

### **11.2 Known Problems with the Data**

None given.

### **11.3 Usage Guidance**

None given.

### **11.4 Other Relevant Information**

Not applicable.

## **12. Application of the Data Set**

None given.

## **13. Future Modifications and Plans**

This data set is in its final format.

## **14. Software**

### **14.1 Software Description**

Not applicable.

### **14.2 Software Access**

Not applicable.

## **15. Data Access**

The TGB-01 NSA SF<sub>6</sub> chamber flux 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](mailto:ornldaac@ornl.gov) or [ornl@eos.nasa.gov](mailto: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**

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### **17.3 Archive/DBMS Usage Documentation**

None.

## **18. Glossary of Terms**

None.

## **19. List of Acronyms**

AES	- Atmospheric Environment Services
ASCII	- American Standard Code for Information Interchange
BOREAS	- BOReal Ecosystem-Atmosphere Study
BORIS	- BOREAS Information System
BP	- Beaver Pond
CD-ROM	- Compact Disk-Read-Only Memory
CMDL	- Climate Monitoring and Diagnostics Laboratory
DAAC	- Distributed Active Archive Center
ECD	- Electron Capture Detector
EOS	- Earth Observing System
EOSDIS	- EOS Data and Information System
FID	- Flame Ionization Detector
GC	- Gas Chromatograph
GIS	- Geographic Information System
GSFC	- Goddard Space Flight Center
HTML	- HyperText Markup Language
NAD83	- North American Datum of 1983
NASA	- National Aeronautics and Space Administration
NSA	- Northern Study Area
OBS	- Old Black Spruce
OJP	- Old Jack Pine
ORNL	- Oak Ridge National Laboratory

PANP	- Prince Albert National Park
SSA	- Southern Study Area
TCD	- Thermal Conductivity Detector
TGB	- Trace Gas Biogeochemistry
URL	- Uniform Resource Locator
YJP	- Young Jack Pine

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