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

Forrest G. Hall and Sara Conrad, Editors

Volume 198

BOREAS TF-4 CO₂ and CH₄ Chamber Flux Data from the SSA

Dean Anderson, Robert Striegl and Kimberly Wickland
U.S. Geological Survey, Denver

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

October 2000
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Summary

The BOREAS TF-4 team measured fluxes of CO₂ and CH₄ across the soil-air interface in four ages of jack pine forest at the BOREAS SSA during August 1993 to March 1995. Gross and net flux of CO₂ and flux of CH₄ between soil and air are presented for 24 chamber sites in mature jack pine forest, 20-year-old, 4-year-old, and clear cut areas. The data are stored in tabular ASCII files.

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1. Data Set Overview

1.1 Data Set Identification
BOREAS TF-04 CO₂ and CH₄ Chamber Flux Data from the SSA

1.2 Data Set Introduction
Data presented in this document were collected at the Old Jack Pine (OJP) and Young Jack Pine (YJP) tower flux sites and nearby clear cut areas at the BOREal Ecosystem-Atmosphere Study (BOREAL) Southern Study Area (SSA). The BOREAS Tower Flux (TF)-04 team measured fluxes of carbon dioxide (CO₂) and methane (CH₄) across the soil-air interface in four ages of jack pine forest at the SSA during August 1993 to March 1995. Gross and net flux of CO₂ and flux of CH₄ between soil and air are presented for 24 chamber sites in mature jack pine forest, 20-year-old and 4-year-old stands, and a clear cut area. The data are stored in tabular American Standard Code for Information Interchange (ASCII) files.
1.3 Objective/Purpose
This study presents data relevant to understanding the transfer and storage of carbon among soil, the unsaturated zone, ground cover vegetation, and understory air in jack pine forest at the SSA. The data were collected continuously from May through September 1994 and during March 1995.

1.4 Summary of Parameters
The primary focus is on the net fluxes of CO₂ and CH₄ measured.

1.5 Discussion
Jack pine woodlands are an important component of the boreal forest, covering more than 2 x 10¹² m² of predominantly well-drained uplands in northern North America. As part of BOREAS, our study objectives were (1) to compare soil respiration at an undisturbed 65- to 90-year-old mature jack pine-lichen woodland with soil respiration at a formerly continuous portion of the stand that was clear-cut harvested during the previous winter, and (2) to identify and quantify the sources of CO₂ and CH₄ production within the soil profile.

1.6 Related Data Sets
BOREAS TGB-01 NSA CH₄ and CO₂ Chamber Flux Data
BOREAS TGB-01 CH₄ Concentration and Flux Data from NSA Tower Sites
BOREAS TGB-01 NSA SF6 Chamber Flux Data
BOREAS TGB-01/TGB-03 CH₄ Chamber Flux Data over the NSA Fen
BOREAS TGB-01/TGB-03 NEE Data over the NSA Fen
BOREAS TGB-03 Plant Species Composition Data over the NSA Fen
BOREAS TGB-03 CH₄ and CO₂ Chamber Flux Data over NSA Upland Sites
BOREAS TF-04 CO₂ and CH₄ Soil Profile Data from the SSA

2. Investigator(s)

2.1 Investigator(s) Name and Title
Dr. Rob Striegl, Hydrologist
United States Geological Survey

Dr. Kimberly Wickland
United States Geological Survey

2.2 Title of Investigation
Automated Measurements of CO₂ Exchange at the Moss Surface of a Black Spruce Forest

2.3 Contact Information

Contact 1:
Dr. Rob Striegl
Hydrologist, United States Geological Survey
P.O. Box 25046 MS 413
Denver, CO 80225
rstriegl@usgs.gov

Contact 2:
Dr. Kimberly P. Wickland
Hydrologist, United States Geological Survey
P.O. Box 25046 MS 413
Denver, CO 80225
3. Theory of Measurements

Atmospheric chemistry measurements and modeling studies identify a global imbalance between known CO₂ production and uptake, with a potentially large terrestrial carbon sink possible in boreal forests. Northern woodlands are also perceived to be very sensitive to climate change. The predicted warming and drying of the boreal region could profoundly affect regional carbon sources and sinks. Carbon cycling of the boreal forest has consequently been a central theme of much recent field research. With the intent of eventually extrapolating land-based carbon, energy, and water flux measurements to the entire boreal forest biome, BOREAS subdivided the northern and southern sections of Canadian boreal forest into aspen, jack pine, and bog-fen landscapes for intensive study. Studies within these vegetation types focused on a variety of factors that influence carbon cycling, including forest stand age and land surface disturbances (Sellers et al., 1995).

Soil respiration, the second largest flux in the global carbon cycle, includes all CO₂ produced by roots, soil organisms, and oxidation that is emitted across the soil-air interface. Although globally important, soil respiration is not well characterized spatially or seasonally for most ecosystems. We derived response curves of measured soil CO₂ emission versus soil temperature for the measurement transects and applied them to soil temperatures that were continuously recorded at the BOREAS OJP flux tower, located approximately 0.2 k, northwest of the OJP transect. This allowed for simulation of continuous soil CO₂ emissions for May-September 1994. The simulation results, when considered with the winter tree removal, the deep well-sorted sandy soil, and the lack of complexity of the plant and soil communities, permitted separation of surface-soil, deep-soil, and tree-root respiration at the OJP stand. The OJP fluxes quantify the amount of CO₂ that is transported across the forest floor and is available for photosynthetic uptake by ground cover and understory plants and trees or for emission to the atmosphere. Because the groundcover was destroyed and all trees were removed by clear-cutting, the "CC" site fluxes represent net CO₂ emission to the atmosphere during the period between forest harvest and re-establishment of plant cover.

4. Equipment

4.1 Sensor/Instrument Description

4.1.1 Collection Environment
Data were collected under all environmental conditions.

4.1.2 Source/Platform
Ground.

4.1.3 Source/Platform Mission Objectives
Support investigators and chambers.
4.1.4 Key Variables
CO₂ and CH₄ flux.

4.1.5 Principles of Operation
CO₂ and CH₄ fluxes were measured by the static chamber technique, which involves measuring the accumulation or loss of gas concentration within chambers placed on the soil surface versus time. The chambers, which are cylindrical with an open bottom and a closed top, are constructed from 0.30-m inside diameter polyvinylchloride (PVC) irrigation pipe. To prevent gas leakage to or from the chambers during measurement, they were affixed by a gasket to a collar, constructed from the same pipe material, that was inserted permanently into the soil to a depth of 0.10 m. When deployed, the collars and chambers had a combined height of 0.28 to 0.30 m. The chambers have a coiled 1.6-mm inside diameter aluminum tube installed through the sidewall near the top to equalize inside and outside pressure and are fitted with various gas ports for air circulation and sample collection. Gross soil CO₂ flux is the total amount of CO₂ that passes across the soil-groundcover/air interface in the absence of photosynthesis. Chambers for measurement of gross CO₂ flux and CH₄ flux have opaque PVC tops that create a dark chamber environment. Net soil CO₂ flux is gross flux minus CO₂ uptake by groundcover photosynthesis. Chambers for measurement of net CO₂ flux have clear polycarbonate tops that are optically transparent across the window of photosynthetically active radiation, allowing plant photosynthesis to occur. Air is recirculated inside the chambers at a rate of 0.25 chamber volume per minute to ensure mixing.

Gross and net CO₂ flux were measured by continuously monitoring the CO₂ concentration in air circulating in a chamber placed on the soil surface. CO₂ concentrations were recorded at 20-second intervals for 8 minutes using a LI-COR 6200 infrared gas analyzer (IRGA).

Soil CH₄ flux was measured by gas chromatograph (GC) analysis of a time series of six syringe samples of air collected from the center of volume of the chamber. Deployment times ranged from 24 to 40 minutes, depending on the anticipated flux rate. Rate of gas emission of consumption were determined by the equation:

$$ J = \frac{dC}{dt} \times h $$

where J is the rate of gas flux across the soil surface (mol/m²/s), C is the gas concentration in the chamber at ambient temperature and pressure (mol/m³), t is time, h is chamber height (m), and dC/dt is the slope of the best fit of the time series of concentration in the chamber as time approaches zero.

4.1.6 Sensor/Instrument Measurement Geometry
Not applicable.

4.1.7 Manufacturer of Sensor/Instrument
The chambers, which are cylindrical with an open bottom and a closed top, are constructed from 0.30 m inside diameter polyvinylchloride (PVC) irrigation pipe. To prevent gas leakage to or from the chambers during measurement, that were affixed by a gasket to a collar, constructed from the same pipe material, that was inserted permanently into the soil to a depth of 0.10 m. When deployed, the collars and chambers had a combined height of 0.28 to 0.30 m. The chambers have a coiled 1.6-mm inside diameter aluminum tube installed through the sidewall near the top to equalize inside and outside pressure and are fitted with various gas ports for air circulation and sample collection.

IRGA, Model 6262
LI-COR, Inc.
Lincoln, NE
4.2 Calibration

4.2.1 Specifications
None given.

4.2.1.1 Tolerance
None given.

4.2.2 Frequency of Calibration

Traceable gas calibration standards for all CO₂ and CH₄ analyses were provided by the BOREAS project.

4.2.3 Other Calibration Information
None given.

5. Data Acquisition Methods

Soil respiration was measured using closed chambers that attached to chamber collars permanently installed in the soil. Three pairs of the 0.38 m diameter chamber collars were inserted 0.10 m into the soil at each site along a 60-m transect, having 30 m between pairs of collars and 1 m between collars within pairs.

Traceable gas calibration standards for all CO₂ and CH₄ analyses were provided by BOREAS operations. CO₂ concentrations were measured using nondispersive IRGAs calibrated to span the expected concentration range. Three different IRGAs were used for measuring CO₂ concentration at the jack pine soil gas transects. Accumulation of CO₂ in soil gas flux chambers was measured using LI-COR model 6200. In situ soil CO₂ concentrations exceed the range of the LI-COR 6200, so two PP System model EGM IRGAs were used, one having a range up to 5000 parts per million (ppm) CO₂ and the second having a range up to 10,000 ppm CO₂.

CH₄ concentrations were measured using a Chrompack model 438A GC having a 2-meter 80-100 mesh Porapak-N column and a flame ionization detector. Carrier gas was nitrogen and the oven temperature was maintained at 38 °C. CH₄ concentrations were calculated from standards curves established from a series of CH₄ Standards run between every 8 to 10 samples. Concentrations smaller than 0.49 ppm were calculated by linear extrapolation of integrator response between a 0.49 ppm CH₄ standard and a nitrogen blank.

The measurements were made by sealing a 0.30-m tall opaque polyvinyl chloride chamber cover over a chamber collar and continuously circulating air from the chamber at top center, through a LI-COR 6200 CO₂ analyzer, and back into the chamber through a perforated air-dispersion ring on the inside of the chamber base. Chamber CO₂ concentrations were measured at 1-s intervals and mean concentrations were recorded at 15-s intervals for 8 minutes. Insertion of the chamber collars into the soil, circulation of chamber air through the gas analyzer, the relatively large chamber diameter, and the relatively short chamber deployment times were all intended to minimize chamber effects known to influence soil gas flux measurements. CO₂ emission rates were calculated using:

\[ J = \frac{dC}{dt} \times h \]

where \( J \) is the rate of CO₂ flux across the soil surface (mol/(m² s)), \( C \) is the CO₂ concentration in the chamber at ambient temperature and pressure (mol/m³), \( t \) is time, \( h \) is chamber height (m), and \( \frac{dC}{dt} \) is the slope of the best fit of the time series of CO₂ concentration in the chamber as time approaches zero.
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 of the sites are:

SSA-OJP: 53.91634° N, 104.69203° W
SSA-YJP: 53.87581° N, 104.64529° W
Clear Cut (CC): 53.9090° N, 104.6595° W
Recent Cut (RC): 53.9091° N, 104.6671° W

7.1.2 Spatial Coverage Map
Not available.

7.1.3 Spatial Resolution
These are point measurements made at the given locations.

7.1.4 Projection
Not applicable.

7.1.5 Grid Description
Not applicable.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

7.2.2 Temporal Coverage Map
Not available.

7.2.3 Temporal Resolution
Gross and net CO₂ flux were measured by continuously monitoring the CO₂ concentration in air circulating in a chamber placed on the soil surface. CO₂ concentrations were recorded at 20-second intervals for 8 minutes using a LI-COR 6200 IRGA.

Soil CH₄ flux was measured by GC analysis of a time series of six syringe samples of air collected from the center of volume of the chamber. Deployment times ranged from 24 to 40 minutes, depending on the anticipated flux rate.
7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data files on the CD-ROM are:

**TF04 CH4 CHAMBER FLUX:**

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<tr>
<th>Column Name</th>
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<td>SITE_NAME</td>
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<td>SUB_SITE</td>
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<tr>
<td>DATE_OBS</td>
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<tr>
<td>TIME_OBS</td>
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<tr>
<td>CHAMBER_ID</td>
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<tr>
<td>CH4_FLUX</td>
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<td>REVISION_DATE</td>
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**TF04 GROSS CO2 CHAMBER FLUX:**

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**TF04 NET CO2 CHAMBER FLUX:**

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<td>SUB_SITE</td>
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<td>DATE_OBS</td>
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<tr>
<td>TIME_OBS</td>
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<tr>
<td>CHAMBER_ID</td>
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<tr>
<td>NET_CO2_FLUX</td>
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<td>REVISION_DATE</td>
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<tr>
<td>CRTFCN_CODE</td>
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7.3.2 Variable Description/Definition

The descriptions of the parameters contained in the data files on the CD-ROM are:

**TF04 CH4 CHAMBER FLUX:**

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<tr>
<th>Column Name</th>
<th>Description</th>
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<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>
</tbody>
</table>
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.

CHAMBER_ID

Identifier assigned to the chamber measured.

CH4_FLUX

Methane flux.

REVISION_DATE

The most recent date when the information in the referenced data base table record was revised.

CRTFCN_CODE

The BOREAS certification level of the data. Exa Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-?? (CPI but questionable).

<table>
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<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 collected.</td>
</tr>
<tr>
<td>CHAMBER_ID</td>
<td>Identifier assigned to the chamber measured.</td>
</tr>
<tr>
<td>GROSS_CO2_FLUX</td>
<td>The gross CO2 flux measured within the chamber.</td>
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<tr>
<td>REVISION_DATE</td>
<td>The most recent date when the information in the referenced data base table record was revised.</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td>The BOREAS certification level of the data. Exa Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-?? (CPI but questionable).</td>
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TF04_NET_CO2_CHAMBER_FLUX:

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<tbody>
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<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>
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<tr>
<td>TIME_OBS</td>
<td>The Greenwich Mean Time (GMT) when the data were collected.</td>
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<tr>
<td>CHAMBER_ID</td>
<td>Identifier assigned to the chamber measured</td>
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<tr>
<td>NET_CO2_FLUX</td>
<td>The net CO2 flux measured within the chamber.</td>
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<td>REVISION_DATE</td>
<td>The most recent date when the information in the referenced data base table record was revised.</td>
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<td>The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).</td>
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7.3.3 Unit of Measurement

The measurement units for the parameters contained in the data files on the CD-ROM are:

TF04_CH4_CHAMBER_FLUX:

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<td>CH4_FLUX</td>
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TF04_GROSS_CO2_CHAMBER_FLUX:

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7.3.4 Data Source

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

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<tr>
<td>SUB_SITE</td>
<td>[Assigned by BORIS Staff]</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>[Investigator]</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>[Investigator]</td>
</tr>
<tr>
<td>CHAMBER_ID</td>
<td>[Investigator]</td>
</tr>
<tr>
<td>GROSS_CO2_FLUX</td>
<td>[LI-COR 6200 CO2 analyzer]</td>
</tr>
<tr>
<td>REVISION_DATE</td>
<td>[Assigned by BORIS Staff]</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td>[Assigned by BORIS Staff]</td>
</tr>
</tbody>
</table>

TF04_NET_CO2_CHAMBER_FLUX:

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>[Assigned by BORIS Staff]</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>[Assigned by BORIS Staff]</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>[Investigator]</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>[Investigator]</td>
</tr>
<tr>
<td>CHAMBER_ID</td>
<td>[Investigator]</td>
</tr>
<tr>
<td>NET_CO2_FLUX</td>
<td>[LI-COR 6200 CO2 analyzer]</td>
</tr>
<tr>
<td>REVISION_DATE</td>
<td>[Assigned by BORIS Staff]</td>
</tr>
<tr>
<td>CRTFCN_CODE</td>
<td>[Assigned by BORIS Staff]</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.

**TF04_CH4_CHAMBER_FLUX:**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Minimum Data Value</th>
<th>Maximum Data Value</th>
<th>Missng Data Value</th>
<th>Unrel Data Value</th>
<th>Below Data Limit</th>
<th>Detect Not Collectd</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>SSA-9JP-CLRCT</td>
<td>SSA-YJP-FLXTR</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>9TF04-FLX01</td>
<td>9TF04-FLX02</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>31-MAY-94</td>
<td>21-MAR-95</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>1420</td>
<td>2341</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>CHAMBER_ID</td>
<td>A</td>
<td>X</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>CH4_FLUX</td>
<td>-643</td>
<td>0</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>REVISION_DATE</td>
<td>09-NOV-98</td>
<td>10-NOV-98</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Blank</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>
</tbody>
</table>

**TF04_GROSS_CO2_CHAMBER_FLUX:**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Minimum Data Value</th>
<th>Maximum Data Value</th>
<th>Missng Data Value</th>
<th>Unrel Data Value</th>
<th>Below Data Limit</th>
<th>Detect Not Collectd</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>SSA-9JP-CLRCT</td>
<td>SSA-YJP-FLXTR</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>9TF04-FLX01</td>
<td>9TF04-FLX02</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>26-MAY-94</td>
<td>20-MAR-95</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>0</td>
<td>2350</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>GROSS_CO2_FLUX</td>
<td>-.18</td>
<td>9.15</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>REVISION_DATE</td>
<td>10-NOV-98</td>
<td>10-NOV-98</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Blank</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>
</tbody>
</table>

**TF04_NET_CO2_CHAMBER_FLUX:**

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Minimum Data Value</th>
<th>Maximum Data Value</th>
<th>Missng Data Value</th>
<th>Unrel Data Value</th>
<th>Below Data Limit</th>
<th>Detect Not Collectd</th>
</tr>
</thead>
<tbody>
<tr>
<td>SITE_NAME</td>
<td>SSA-9JP-CLRCT</td>
<td>SSA-YJP-FLXTR</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>SUB_SITE</td>
<td>9TF04-FLX01</td>
<td>9TF04-FLX02</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>DATE_OBS</td>
<td>02-JUN-94</td>
<td>15-SEP-94</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>TIME_OBS</td>
<td>234</td>
<td>2308</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>CHAMBER_ID</td>
<td>A</td>
<td>X</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>NET_CO2_FLUX</td>
<td>-1.82</td>
<td>6.63</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>REVISION_DATE</td>
<td>10-NOV-98</td>
<td>10-NOV-98</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>
</tbody>
</table>

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...
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 Collectd -- 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.

**TF04_CH4_CHAMBER_FLUX:**

<table>
<thead>
<tr>
<th>SITE_NAME, SUB_SITE, DATE_OBS, TIME_OBS, CHAMBER_ID, CH4_FLUX, REVISION_DATE, CRTFCN_CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>'SSA-9JP-CLRCT', '9TF04-FLX01', 10-JUN-94, 1643, 'V', -158.0, 09-NOV-98, 'CPI'</td>
</tr>
<tr>
<td>'SSA-9JP-CLRCT', '9TF04-FLX01', 10-JUN-94, 1644, 'U', -76.0, 09-NOV-98, 'CPI'</td>
</tr>
</tbody>
</table>

**TF04_GROSS_CO2_CHAMBER_FLUX:**

<table>
<thead>
<tr>
<th>SITE_NAME, SUB_SITE, DATE_OBS, TIME_OBS, CHAMBER_ID, GROSS_CO2_FLUX, REVISION_DATE, CRTFCN_CODE</th>
</tr>
</thead>
</table>

**TF04_NET_CO2_CHAMBER_FLUX:**

<table>
<thead>
<tr>
<th>SITE_NAME, SUB_SITE, DATE_OBS, TIME_OBS, CHAMBER_ID, NET_CO2_FLUX, REVISION_DATE, CRTFCN_CODE</th>
</tr>
</thead>
</table>
8. Data Organization

8.1 Data Granularity
The smallest unit of data tracked by the BOREAS Information System (BORIS) is the measurement(s) made for a given site at a given time.

8.2 Data Format(s)
The Compact Disk-Read-Only Memory (CD-ROM) files contain 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
CO$_2$ emission rates were calculated using $J = \frac{dC}{dt} x h$, where $J$ is the rate of CO$_2$ flux across the soil surface (mol/(m$^2$ s)), $C$ is the CO$_2$ concentration in the chamber at ambient temperature and pressure (mol/m$^3$), $t$ is time, $h$ is chamber height (m), and $dC/dt$ is the slope of the best fit of the time series of CO$_2$ concentration in the chamber as time approaches zero.

9.4 Graphs and Plots
None given.
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
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 given.

11.4 Other Relevant Information
None given.

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
Not applicable.

15. Data Access

The CO₂ and CH₄ 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: ornl daarac@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 given.

17.2 Journal Articles and Study Reports


17.3 Archive/DBMS Usage Documentation
None.

18. Glossary of Terms
None.
19. List of Acronyms

ASCII - American Standard Code for Information Interchange
BOREALIS - BOREAL Ecosystem-Atmosphere Study
BORIS - BOREAS Information System
CC - Clear Cut site
CD-ROM - Compact Disk-Read-Only Memory
DAAC - Distributed Active Archive Center
EOS - Earth Observing System
EOSDIS - EOS Data and Information System
GC - Gas Chromatograph
GIS - Geographic Information System
GMT - Greenwich Mean Time
GSFC - Goddard Space Flight Center
HTML - HyperText Markup Language
IRGA - Infrared Gas Analyzer
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
PPFD - Photosynthetically Active Photon Flux Density
PVC - Polyvinylchloride
RC - Recently Cut site
SSA - Southern Study Area
TF - Tower Flux
TGB - Trace Gas Biochemistry
URL - Uniform Resource Locator
YJP - Young Jack Pine

20. Document Information

20.1 Document Revision Date
Written: 01-Dec-1998
Last Updated: 20-Aug-1999

20.2 Document Review Date(s)
BORIS Review: 03-Dec-1998
Science Review:

20.3 Document ID
20.4 Citation

When using these data, please include the following acknowledgment as well as citations of relevant papers in Section 17.2:


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


Also, cite the BOREAS CD-ROM set as:


20.5 Document Curator

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

BOREAS TF-4 CO₂ and CH₄ Chamber Flux Data from the SSA

**AUTHOR(S)**

Dean Anderson, Robert Striegl and Kimberly Wickland
Forrest G. Hall and Sara Conrad, Editors

**PERFORMING ORGANIZATION NAME(S) AND ADDRESS (ES)**

Goddard Space Flight Center
Greenbelt, Maryland 20771

The BOREAS TF-4 team measured fluxes of CO₂ and CH₄ across the soil-air interface in four ages of jack pine forest at the BOREAS SSA during August 1993 to March 1995. Gross and net flux of CO₂ and flux of CH₄ between soil and air are presented for 24 chamber sites in mature jack pine forest, 20-year-old, 4-year-old, and clear cut areas. The data are stored in tabular ASCII files.