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

Forrest G. Hall and Sara Conrad, Editors

Volume 199

BOREAS TF-4 CO₂ and CH₄ Soil Profile Data from the SSA

*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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BOREAS TF-4 CO₂ and CH₄ Soil Profile Data from the SSA

Rob Striegl, Kimberly P. Wickland

Summary

The BOREAS TF-4 team measured distributions of carbon dioxide (CO₂) and methane (CH₄) concentrations for the upper 5 m of soil and unsaturated zone at the mature stand, upper 6 m at the 20-year-old stand, and the upper 1 m at the 8-year-old stand and clear cut area at the BOREAS SSA during August 1993 to March 1995. Particle size and carbon content of the unsaturated deposits, precipitation, soil temperature and moisture, carbon and oxygen isotopes of soil CO₂, and soil water chemistry are also presented. 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 Soil Profile 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 (BOREAS) Southern Study Area (SSA). The BOREAS Tower Flux (TF)-04 team measured distributions of carbon dioxide (CO₂) and methane (CH₄) concentrations for the upper 5 m of soil and unsaturated zone at the mature stand, upper 6 m at the 20-year-old stand, and the upper 1 m at the 8-year-old stand and clear cut area at the SSA during August 1993 to March 1995. Particle size and carbon content of the unsaturated deposits, precipitation, soil temperature and moisture, carbon and oxygen isotopes of soil CO₂, and soil water chemistry are also presented. 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 concentrations of soil CO₂ and CH₄ measured.

1.5 Discussion

Jack pine woodlands are an important component of the boreal forest, covering more than 2×10^{12} 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/TGB-03 CH₄ Chamber Flux Data over the NSA Fen
BOREAS TGB-03 Plant Species Composition Data over the NSA Fen
BOREAS TGB-01/TGB-03 NEE Data over the NSA Fen
BOREAS TGB-03 CH₄ and CO₂ Chamber Flux Data over NSA Upland Sites
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

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

Measurements of Soil Carbon Dioxide and Methane Concentrations and Fluxes, and Soil Properties at Four Ages of Jack Pine Forest in the Southern Study Area of the Boreal Ecosystem Atmosphere Study, Saskatchewan, Canada, 1993-95

2.3 Contact Information

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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.

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 soil probes.

4.1.4 Key Variables

CO₂ and CH₄ concentrations.

4.1.5 Principles of Operation

Soil surface temperature was measured using a Fluke model 51 K thermometer at three depths (0.05, 0.10, and 0.15 m) at each pair of chambers in conjunction with flux measurements.

Soil water content was determined from soil samples collected at each pair of chambers concurrent with flux measurements. Each sample included the top 0.05 m of soil and was sealed in an air-tight container until analysis. The samples were weighed, oven-dried at 105 °C for approximately 24 hours, and weighed again. After subtracting the container weight, percent water content was calculated as the difference of the original sample weight and the dried sample weight divided by the original sample weight and multiplied by 100 (Klute, 1986).

Concentrations CO₂ and CH₄ in soil gas were measured at chamber pairs at each of the four transects using 2.0-mm inside diameter stainless steel probes. The probes were inserted to soil depths ranging from 0.02 m to 0.50 m, and soil gas was collected using nylon syringes. CO₂ concentration was analyzed onsite using a PP Systems model EGM infrared gas analyzer (IRGA), and CH₄ concentration was analyzed by gas chromatography using methods described above. Soil gas collection was concurrent with chamber measurements.

In addition to the chamber pair probe measurements, each site had a series of permanent probes installed for soil gas collection. The OJP site had permanent probes installed within 10 m of the first chamber pair (GH) to a maximum depth of 3.4 m. The YJP site had permanent probes installed within 10 m of the first chamber pair (AB) to a maximum depth of 6.0 m. Additional probes were located 5 m south of the YJP instrument shelter.

Soil gas was collected from three series of depths in the unsaturated zone at YJP. CO₂, extracted from the gas by cryogenic trapping, was analyzed for ¹³C and ¹⁸O content using mass spectrometry at the U.S. Geological Survey gas isotope laboratory in Denver, CO. Values were obtained from samples collected on one occasion. Stable isotope values are presented in delta notation in units of the parts per thousand relative difference (permil) between the ratios of ¹³C to ¹²C and ¹⁸O to ¹⁶O in the samples and Pee Dee belemnite for ¹³C and Standard Mean Ocean Water for ¹⁸O.

Gravity drainage lysimeters were installed at the YJP and OJP sites to collect liquid water percolating through the unsaturated sands to a maximum depth of 1.00 m. Only one rainfall event (day 200, 1994) was large enough to initiate sufficient percolation at the YJP site for water sample collection and analysis. Sufficient water volume was never collected at the OJP site.

4.1.6 Sensor/Instrument Measurement Geometry

Not applicable.

4.1.7 Manufacturer of Sensor/Instrument

Concentrations CO₂ and CH₄ in soil gas were measured at chamber pairs at each of the four transects using 2.0-mm inside diameter stainless steel probes. The probes were inserted to soil depths ranging from 0.02 m to 0.50 m, and soil gas was collected using nylon syringes.

- PP Systems model EGM IRGA
- Fluke model 51 K thermometer

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 BOREAS operations.

4.2.3 Other Calibration Information

None given.

5. Data Acquisition Methods

Soil surface temperature was measured using a Fluke model 51 K thermometer at three depths (0.05, 0.10, and 0.15 m) at each pair of chambers in conjunction with flux measurements.

Soil water content was determined from soil samples collected at each pair of chambers concurrent with flux measurements. Each sample included the top 0.05 m of soil and was sealed in an air-tight container until analysis. The samples were weighed, oven-dried at 105 °C for approximately 24 hours, and weighed again. After subtracting the container weight, percent water content was calculated as the difference of the original sample weight and the dried sample weight divided by the original sample weight and multiplied by 100 (Klute, 1986).

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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

The data set covers the period from 26-May-1994 to 21-Mar-1995.

7.2.2 Temporal Coverage Map

Not available.

7.2.3 Temporal Resolution

Soil gas collection was concurrent with chamber measurements.

7.3 Data Characteristics

7.3.1 Parameter/Variable

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

TF04_SOIL_CARBON

Column Name

SITE_NAME
SUB_SITE
DATE_OBS
DEPTH_INTERVAL
TOTAL_CARBON_CONTENT
INORGANIC_CARBON_CONTENT
CRTFCN_CODE
REVISION_DATE

TF04_SOIL_CH4_PROFILE

Column Name

SITE_NAME
SUB_SITE
DATE_OBS
CHAMBER_ID
SOIL_DEPTH
CH4_CONC
REVISION_DATE
CRTFCN_CODE

TF04_SOIL_CO2_ISOTOPE

Column Name

SITE_NAME
SUB_SITE
DATE_OBS
CHAMBER_ID
SOIL_DEPTH
DEL_13C
DEL_18O
CO2_CONC
CRTFCN_CODE
REVISION_DATE

TF04_SOIL_CO2_PROFILE

Column Name

SITE_NAME
SUB_SITE
DATE_OBS
CHAMBER_ID
SOIL_DEPTH
CO2_CONC
REVISION_DATE
CRTFCN_CODE

TF04_SOIL_TEMP_MOIST

Column Name

SITE_NAME
SUB_SITE
DATE_OBS
TIME_OBS
CHAMBER_ID
AIR_TEMP
SOIL_TEMP_5CM
SOIL_TEMP_10CM
SOIL_TEMP_15CM
SOIL_WATER_CONTENT
CRTFCN_CODE
REVISION_DATE

TF04_SOIL_WATER_CHEM

Column Name

SITE_NAME
 SUB_SITE
 DATE_OBS
 SOIL_DEPTH
 TOT_ORG_C_CONC
 TOT_INORG_C_CONC
 ACID_NEUTRALIZING_CAPACITY
 ELECTRIC_CONDUCTIVITY
 SODIUM_EQUIV
 AMMONIUM_EQUIV
 POTASSIUM_EQUIV
 MAGNESIUM_EQUIV
 CALCIUM_EQUIV
 CHLORIDE_EQUIV
 NITRATE_EQUIV
 SULFATE_EQUIV
 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:

TF04_SOIL_CARBON

Column Name

Description

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.
DEPTH_INTERVAL	The range of depths at which the soil carbon measurements were taken.
TOTAL_CARBON_CONTENT	The percent total carbon content by weight of the sample.
INORGANIC_CARBON_CONTENT	The percent inorganic carbon content by weight of the sample.
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.

TF04_SOIL_CH4_PROFILE

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-IIIIV, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIIV is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
CHAMBER_ID	Identifier assigned to the chamber measured
SOIL_DEPTH	The depth below the soil surface at which the measurement was taken.
CH4_CONC	CH4 concentration.
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.

TF04_SOIL_CO2_ISOTOPE

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-IIIIV, where GGGGG is the group associated with the sub-site instrument, e.g. HYD06 or STAFF, and IIIIV is the identifier for sub-site, often this will refer to an instrument.
DATE_OBS	The date on which the data were collected.
CHAMBER_ID	Identifier assigned to the chamber measured
SOIL_DEPTH	The depth below the soil surface at which the measurement was taken.
DEL_13C	The del 13C is a relative difference between the sample and the PeeDee Belemnite standard, relative to the PeeDee Belemnite standard.
DEL_18O	The del 18O is a relative difference between the sample and the SMOW standard, relative to the SMOW standard.

CO2_CONC	CO2 concentration.
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.

TF04_SOIL_CO2_PROFILE

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.
CHAMBER_ID	Identifier assigned to the chamber measured
SOIL_DEPTH	The depth below the soil surface at which the measurement was taken.
CO2_CONC	CO2 concentration.
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.

TF04_SOIL_TEMP_MOIST

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

CHAMBER_ID	collected.
AIR_TEMP	Identifier assigned to the chamber measured
SOIL_TEMP_5CM	The air temperature.
SOIL_TEMP_10CM	Soil temperature measured at a depth of 5 cm.
SOIL_TEMP_15CM	Soil temperature at a depth of 10 cm.
SOIL_WATER_CONTENT	Soil temperature at a depth of 15 cm.
	The water content of the soil, measured at the top 0.05 meters of soil, reported in percent weight.
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.

TF04_SOIL_WATER_CHEM

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.
SOIL_DEPTH	The depth below the soil surface at which the measurement was taken.
TOT_ORG_C_CONC	The total organic carbon concentration in the soil water
TOT_INORG_C_CONC	Total inorganic carbon concentration in the soil water.
ACID_NEUTRALIZING_CAPACITY	The acid neutralizing capacity of the soil water.
ELECTRIC_CONDUCTIVITY	The electric conductivity of the soil sample.
SODIUM_EQUIV	Microequivalents of Sodium charge per liter of soil water
AMMONIUM_EQUIV	Microequivalents of Ammonium charge per liter of soil water
POTASSIUM_EQUIV	Microequivalents of Potassium charge per liter of soil water
MAGNESIUM_EQUIV	Microequivalents of magnesium charge per liter of soil water
CALCIUM_EQUIV	Microequivalents of calcium charge per liter of soil water
CHLORIDE_EQUIV	Microequivalents of chloride charge per liter of soil water
NITRATE_EQUIV	Microequivalents of nitrate charge per liter of

SULFATE_EQUIV	soil water Microequivalents of sulfate charge per liter of soil water
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:

TF04_SOIL_CARBON

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
DEPTH_INTERVAL	[meters]
TOTAL_CARBON_CONTENT	[percent]
INORGANIC_CARBON_CONTENT	[percent]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

TF04_SOIL_CH4_PROFILE

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
CHAMBER_ID	[none]
SOIL_DEPTH	[millimeters]
CH4_CONC	[parts per million]
REVISION_DATE	[DD-MON-YY]
CRTFCN_CODE	[none]

TF04_SOIL_CO2_ISOTOPE

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
CHAMBER_ID	[none]
SOIL_DEPTH	[millimeters]
DEL_13C	[per mil]
DEL_18O	[per mil]
CO2_CONC	[parts per million]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

TF04_SOIL_CO2_PROFILE

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
CHAMBER_ID	[none]
SOIL_DEPTH	[millimeters]
CO2_CONC	[parts per million]
REVISION_DATE	[DD-MON-YY]
CRTFCN_CODE	[none]

TF04_SOIL_TEMP_MOIST

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
TIME_OBS	[HHMM GMT]
CHAMBER_ID	[none]
AIR_TEMP	[degrees Celsius]
SOIL_TEMP_5CM	[degrees Celsius]
SOIL_TEMP_10CM	[degrees Celsius]
SOIL_TEMP_15CM	[degrees Celsius]
SOIL_WATER_CONTENT	[percent]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

TF04_SOIL_WATER_CHEM

Column Name	Units
SITE_NAME	[none]
SUB_SITE	[none]
DATE_OBS	[DD-MON-YY]
SOIL_DEPTH	[millimeters]
TOT_ORG_C_CONC	[milligrams][liter ⁻¹ soil water]
TOT_INORG_C_CONC	[milligrams][liter ⁻¹ soil water]
ACID_NEUTRALIZING_CAPACITY	[microequivalents][liter ⁻¹ soil water]
ELECTRIC_CONDUCTIVITY	[siemens][meter ⁻¹]
SODIUM_EQUIV	[microequivalents charge][liter ⁻¹ soil water]
AMMONIUM_EQUIV	[microequivalents charge][liter ⁻¹ soil water]
POTASSIUM_EQUIV	[microequivalents charge][liter ⁻¹ soil water]
MAGNESIUM_EQUIV	[microequivalents charge][liter ⁻¹ soil water]
CALCIUM_EQUIV	[microequivalents charge][liter ⁻¹ soil water]
CHLORIDE_EQUIV	[microequivalents charge][liter ⁻¹ soil water]
NITRATE_EQUIV	[microequivalents charge][liter ⁻¹ soil water]
SULFATE_EQUIV	[microequivalents charge][liter ⁻¹ soil water]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

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

TF04_SOIL_CARBON

Column Name	Data Source
SITE_NAME	[Assigned by BORIS Staff]
SUB_SITE	[Assigned by BORIS Staff]
DATE_OBS	[Investigator]
DEPTH_INTERVAL	[Investigator]
TOTAL_CARBON_CONTENT	[BY WEIGHT]
INORGANIC_CARBON_CONTENT	[BY WEIGHT]
REVISION_DATE	[Assigned by BORIS Staff]
CRTFCN_CODE	[Assigned by BORIS Staff]

TF04_SOIL_CH4_PROFILE

Column Name	Data Source
SITE_NAME	[Assigned by BORIS Staff]
SUB_SITE	[Assigned by BORIS Staff]
DATE_OBS	[Investigator]
CHAMBER_ID	[Investigator]
SOIL_DEPTH	[Investigator]
CH4_CONC	[Gas Chromatograph]
REVISION_DATE	[Assigned by BORIS Staff]
CRTFCN_CODE	[Assigned by BORIS Staff]

TF04_SOIL_CO2_ISOTOPE

Column Name	Data Source
SITE_NAME	[Assigned by BORIS Staff]
SUB_SITE	[Assigned by BORIS Staff]
DATE_OBS	[Investigator]
CHAMBER_ID	[Investigator]
SOIL_DEPTH	[Investigator]
DEL_13C	[mass spectrometry]
DEL_18O	[mass spectrometry]
CO2_CONC	[PP Systems model EGM IRGA]
REVISION_DATE	[Assigned by BORIS Staff]
CRTFCN_CODE	[Assigned by BORIS Staff]

TF04_SOIL_CO2_PROFILE

Column Name	Data Source
SITE_NAME	[Assigned by BORIS Staff]
SUB_SITE	[Assigned by BORIS Staff]
DATE_OBS	[Investigator]
CHAMBER_ID	[Investigator]
SOIL_DEPTH	[Investigator]
CO2_CONC	[PP Systems model EGM IRGA]
REVISION_DATE	[Assigned by BORIS Staff]
CRTFCN_CODE	[Assigned by BORIS Staff]

TF04_SOIL_TEMP_MOIST

Column Name	Data Source
SITE_NAME	[Assigned by BORIS Staff]
SUB_SITE	[Assigned by BORIS Staff]
DATE_OBS	[Investigator]
TIME_OBS	[INVESTIGATOR]
CHAMBER_ID	[Investigator]
AIR_TEMP	[Fluke model 51 K thermometer]
SOIL_TEMP_5CM	[Fluke model 51 K thermometer]
SOIL_TEMP_10CM	[Fluke model 51 K thermometer]
SOIL_TEMP_15CM	[Fluke model 51 K thermometer]
SOIL_WATER_CONTENT	[By weight]
REVISION_DATE	[Assigned by BORIS Staff]
CRTFCN_CODE	[Assigned by BORIS Staff]

TF04_SOIL_WATER_CHEM

Column Name	Data Source
SITE_NAME	[Assigned by BORIS Staff]
SUB_SITE	[Assigned by BORIS Staff]
DATE_OBS	[Investigator]
SOIL_DEPTH	[Investigator]
TOT_ORG_C_CONC	[BY WEIGHT]
TOT_INORG_C_CONC	[BY WEIGHT]
ACID_NEUTRALIZING_CAPACITY	[PLEASE COMPLETE]
ELECTRIC_CONDUCTIVITY	[Conductivity meter]
SODIUM_EQUIV	[According to Fishman and Friedman (1985)]
AMMONIUM_EQUIV	[According to Fishman and Friedman (1985)]
POTASSIUM_EQUIV	[According to Fishman and Friedman (1985)]
MAGNESIUM_EQUIV	[According to Fishman and Friedman (1985)]
CALCIUM_EQUIV	[According to Fishman and Friedman (1985)]
CHLORIDE_EQUIV	[According to Fishman and Friedman (1985)]
NITRATE_EQUIV	[According to Fishman and Friedman (1985)]
SULFATE_EQUIV	[According to Fishman and Friedman (1985)]
REVISION_DATE	[Assigned by BORIS Staff]
CRTFCN_CODE	[Assigned by BORIS Staff]

7.3.5 Data Range

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

TF04_SOIL_CARBON

	Minimum	Maximum	Missng	Unrel	Below	Data
Column Name	Data	Data	Data	Data	Detect	Not
	Value	Value	Value	Value	Limit	Clldtd
SITE_NAME	SSA-OJP-FLXTR	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TF04-SPR01	9TF04-SPR01	None	None	None	None
DATE_OBS	22-MAY-94	21-AUG-94	None	None	None	None
DEPTH_INTERVAL	0-0.02	9.14	None	None	None	None
TOTAL_CARBON_CONTENT	.0236	1.1932	-999	None	None	None
INORGANIC_CARBON_CONTENT	0	1.159	None	None	None	None

CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	12-NOV-98	12-NOV-98	None	None	None	None

TF04_SOIL_CH4_PROFILE

	Minimum	Maximum	Missng	Unrel	Below	Data
	Data	Data	Data	Data	Detect	Not
Column Name	Value	Value	Value	Value	Limit	Cllctd
SITE_NAME	SSA-9JP-CLRCT	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TF04-SPR01	9TF04-SPR01	None	None	None	None
DATE_OBS	27-MAY-94	21-MAR-95	None	None	None	None
CHAMBER_ID	AB	YJP	None	None	None	None
SOIL_DEPTH	-6	0	None	None	None	None
CH4_CONC	.01	2.58	-999	-888	None	Blank
REVISION_DATE	12-NOV-98	12-NOV-98	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None

TF04_SOIL_CO2_ISOTOPE

	Minimum	Maximum	Missng	Unrel	Below	Data
	Data	Data	Data	Data	Detect	Not
Column Name	Value	Value	Value	Value	Limit	Cllctd
SITE_NAME	SSA-YJP-FLXTR	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TF04-SPR01	9TF04-SPR01	None	None	None	None
DATE_OBS	23-AUG-94	23-AUG-94	None	None	None	None
CHAMBER_ID	AH 1	UZ 6	None	None	None	None
SOIL_DEPTH	-6	-.1	None	None	None	None
DEL_13C	-21.29	-10.1	None	None	None	None
DEL_18O	20.65	28.94	None	None	None	None
CO2_CONC	1941	5980	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE			None	None	None	Blank

TF04_SOIL_CO2_PROFILE

	Minimum	Maximum	Missng	Unrel	Below	Data
	Data	Data	Data	Data	Detect	Not
Column Name	Value	Value	Value	Value	Limit	Cllctd
SITE_NAME	SSA-9JP-CLRCT	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TF04-SPR01	9TF04-SPR01	None	None	None	None
DATE_OBS	26-MAY-94	21-MAR-95	None	None	None	None
CHAMBER_ID	MN	YJP	None	None	None	None
SOIL_DEPTH	-6	0	None	None	None	None
CO2_CONC	359	21110	-999	None	None	None
REVISION_DATE	12-NOV-98	12-NOV-98	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None

TF04_SOIL_TEMP_MOIST

	Minimum	Maximum	Missng	Unrel	Below	Data
	Data	Data	Data	Data	Detect	Not
Column Name	Value	Value	Value	Value	Limit	Cllctd
SITE_NAME	SSA-9JP-CLRCT	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TF04-SPR01	9TF04-SPR01	None	None	None	None
DATE_OBS	22-MAY-94	18-SEP-94	None	None	None	None
TIME_OBS	0	930	None	None	None	None
CHAMBER_ID	AB	WX	None	None	None	None
AIR_TEMP	2.4	35.1	-999	None	None	None
SOIL_TEMP_5CM	9.1	27.3	-999	None	None	None
SOIL_TEMP_10CM	8.3	21.4	-999	None	None	None
SOIL_TEMP_15CM	1.5	19.7	-999	None	None	None
SOIL_WATER_CONTENT	.89	24.58	-999	None	None	Blank
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	12-NOV-98	12-NOV-98	None	None	None	None

TF04_SOIL_WATER_CHEM

	Minimum	Maximum	Missng	Unrel	Below	Data
	Data	Data	Data	Data	Detect	Not
Column Name	Value	Value	Value	Value	Limit	Cllctd
SITE_NAME	SSA-YJP-FLXTR	SSA-YJP-FLXTR	None	None	None	None
SUB_SITE	9TF04-SPR01	9TF04-SPR01	None	None	None	None
DATE_OBS	19-JUL-94	19-JUL-94	None	None	None	None
SOIL_DEPTH	-1	-.1	None	None	None	None
TOT_ORG_C_CONC	9.05	74	None	None	None	None
TOT_INORG_C_CONC	.94	15.65	-999	None	None	None
ACID_NEUTRALIZING_	421.15	2494.7	None	None	None	None
CAPACITY						
ELECTRIC_	58.3	238	None	None	None	None
CONDUCTIVITY						
SODIUM_EQUIV	21.018	36.233	None	None	None	None
AMMONIUM_EQUIV	.746	2.516	None	None	None	None
POTASSIUM_EQUIV	4.346	9.582	None	None	None	None
MAGNESIUM_EQUIV	18.843	67.865	None	None	None	None
CALCIUM_EQUIV	42.5	158.607	None	None	None	None
CHLORIDE_EQUIV	5.45	9.42	None	None	None	None
NITRATE_EQUIV	.88	1.24	None	None	None	None
SULFATE_EQUIV	4.28	14.12	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	10-NOV-98	10-NOV-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.

TF04_SOIL_CARBON

```
SITE_NAME,SUB_SITE,DATE_OBS,DEPTH_INTERVAL,TOTAL_CARBON_CONTENT,
INORGANIC_CARBON_CONTENT,CRTFCN_CODE,REVISION_DATE
'SSA-OJP-FLXTR','9TF04-SPR01',22-MAY-94,'0-0.02',1.1932,.0094,'CPI',12-NOV-98
'SSA-OJP-FLXTR','9TF04-SPR01',22-MAY-94,'0-0.1',.3754,.004,'CPI',12-NOV-98
'SSA-OJP-FLXTR','9TF04-SPR01',22-MAY-94,'0.1-0.3',.0762,.0008,'CPI',12-NOV-98
'SSA-OJP-FLXTR','9TF04-SPR01',22-MAY-94,'0.3-0.6',.041,.0006,'CPI',12-NOV-98
```

TF04_SOIL_CH4_PROFILE

```
SITE_NAME,SUB_SITE,DATE_OBS,CHAMBER_ID,SOIL_DEPTH,CH4_CONC,REVISION_DATE,
CRTFCN_CODE
'SSA-9JP-CLRCT','9TF04-SPR01',05-JUN-94,'ST',0.0,-999.0,12-NOV-98,'CPI'
'SSA-9JP-CLRCT','9TF04-SPR01',05-JUN-94,'ST',-.1,1.56,12-NOV-98,'CPI'
```

TF04_SOIL_CO2_ISOTOPE

```
SITE_NAME,SUB_SITE,DATE_OBS,CHAMBER_ID,SOIL_DEPTH,DEL_13C,DEL_18O,CO2_CONC,
CRTFCN_CODE,REVISION_DATE
'SSA-YJP-FLXTR','9TF04-SPR01',23-AUG-94,'UZ 1',-1.0,-10.1,27.73,4232.0,'CPI',
10-NOV-98
'SSA-YJP-FLXTR','9TF04-SPR01',23-AUG-94,'UZ 2',-2.0,-20.41,20.68,4057.0,'CPI',
10-NOV-98
'SSA-YJP-FLXTR','9TF04-SPR01',23-AUG-94,'UZ 3',-3.0,-20.47,23.57,3547.0,'CPI',
10-NOV-98
```

TF04_SOIL_CO2_PROFILE

```
SITE_NAME,SUB_SITE,DATE_OBS,CHAMBER_ID,SOIL_DEPTH,CO2_CONC,REVISION_DATE,
CRTFCN_CODE
'SSA-9JP-CLRCT','9TF04-SPR01',05-JUN-94,'ST',0.0,-999.0,12-NOV-98,'CPI'
'SSA-9JP-CLRCT','9TF04-SPR01',05-JUN-94,'ST',-.1,570.0,12-NOV-98,'CPI'
'SSA-9JP-CLRCT','9TF04-SPR01',05-JUN-94,'ST',-.1,621.0,12-NOV-98,'CPI'
'SSA-9JP-CLRCT','9TF04-SPR01',05-JUN-94,'ST',-.2,-999.0,12-NOV-98,'CPI'
'SSA-9JP-CLRCT','9TF04-SPR01',05-JUN-94,'ST',-.2,826.0,12-NOV-98,'CPI'
```

TF04_SOIL_TEMP_MOIST

SITE_NAME, SUB_SITE, DATE_OBS, TIME_OBS, CHAMBER_ID, AIR_TEMP, SOIL_TEMP_5CM,
SOIL_TEMP_10CM, SOIL_TEMP_15CM, SOIL_WATER_CONTENT, CRTFCN_CODE, REVISION_DATE
'SSA-9JP-CLRCT', '9TF04-SPR01', 26-MAY-94, 330, 'ST', -999.0, 16.5, 13.3, 11.3, 8.83,
'CPI', 12-NOV-98
'SSA-9JP-CLRCT', '9TF04-SPR01', 26-MAY-94, 330, 'UV', -999.0, 15.1, 13.7, 11.5, 11.91,
'CPI', 12-NOV-98

TF04_SOIL_WATER_CHEM

SITE_NAME, SUB_SITE, DATE_OBS, SOIL_DEPTH, TOT_ORG_C_CONC, TOT_INORG_C_CONC,
ACID_NEUTRALIZING_CAPACITY, ELECTRIC_CONDUCTIVITY, SODIUM_EQUIV, AMMONIUM_EQUIV,
POTASSIUM_EQUIV, MAGNESIUM_EQUIV, CALCIUM_EQUIV, CHLORIDE_EQUIV, NITRATE_EQUIV,
SULFATE_EQUIV, CRTFCN_CODE, REVISION_DATE
'SSA-YJP-FLXTR', '9TF04-SPR01', 19-JUL-94, -.3, 74.0, .94, 421.15, 72.6, 24.014,
2.516, 7.262, 19.751, 53.038, 5.45, .91, 5.79, 'CPI', 10-NOV-98
'SSA-YJP-FLXTR', '9TF04-SPR01', 19-JUL-94, -.8, 36.58, 8.6, 1408.44, 158.1,
21.018, .746, 4.346, 40.496, 107.1, 9.42, .88, 14.12, 'CPI', 10-NOV-98

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

None.

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

See Section 10.1.

11.3 Usage Guidance

See Section 10.1.

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 soil profile 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 Platform/Sensor/Instrument/Data Processing Documentation

Klute, A. (Ed.). 1986. Methods of Soil Analysis, Part I: Physical and Mineralogical Methods, Agronomy Monograph no. 9 (2nd Ed.) American Society of Agronomy. Madison, WI.

17.2 Journal Articles and Study Reports

Fishman M.J. and L.C. Fiedman. 1985. Methods of determination of inorganic substances in water and fluvial sediments. Techniques of Water Resources Investigations of the U.S. Geological Survey. Book 5 Chapter A1, 5445 p.

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

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

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

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

Striegl, R.G. and K.P. Wickland. 1998. Effects of a clear-cut harvest on soil respiration in a jack-pine lichen woodland. Can. Jour. Forest Research 28:534-539.

Wickland, K.P. and R.G. Striegl. 1997. Measurements of soil carbon dioxide and methane concentrations and fluxes, and soil properties at four ages of jack pine forest in the Southern Study Area of the Boreal Ecosystem Atmosphere Study, Saskatchewan, Canada, 1993-1995. U.S. Geological Survey Open-File Report. 97-49.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

ASCII	- American Standard Code for Information Interchange
BOREAS	- 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
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
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: 09-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:

Wickland, K.P. and R.G. Striegl. 1997. Measurements of soil carbon dioxide and methane concentrations and fluxes, and soil properties at four ages of jack pine forest in the Southern Study Area of the Boreal Ecosystem Atmosphere Study, Saskatchewan, Canada, 1993-1995. U.S. Geological Survey Open-File Report. 97-49.

Striegl, R.G. and K.P. Wickland. 1998. effects of a clear-cut harvest on soil respiration in a jack-pine lichen woodland, Can. Jour. Forest Research 28:534-539.

Fishman M.J. and L.C. Fiedman. 1985. Methods of determination of inorganic substances in water and fluvial sediments. Techniques of Water Resources Investigations of the U.S. Geological Survey. Book 5 Chapter A1, 5445 p.

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

Striegl, R. and K. Wickland, "Measurements of Soil Carbon Dioxide and Methane Concentrations and Fluxes, and Soil Properties at Four Ages of Jack Pine Forest in the Southern Study Area of the Boreal Ecosystem Atmosphere Study, Saskatchewan, Canada, 1993-95." 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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