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

Forrest G. Hall and David E. Knapp, Editors

Volume 7

BOREAS AFM-04 Twin Otter Aircraft Sounding Data

J.I. MacPherson and R.L. Desjardins

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Available from:

BOREAS AFM-4 Twin Otter Aircraft Sounding Data

J. Ian MacPherson, Raymond L. Desjardins

Summary

The BOREAS AFM-4 team used the NRC Twin Otter aircraft to make sounding measurements through the boundary layer. These measurements included concentrations of carbon dioxide and ozone, atmospheric pressure, dry bulb temperature, potential temperature, dewpoint temperature, calculated mixing ratio, and wind speed and direction. Aircraft position, heading, and altitude were also recorded. Data were collected at both the NSA and the SSA in 1994 and 1996. These data are stored in tabular ASCII files.

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BOREAS AFM-04 Twin Otter Aircraft Sounding Data

1.2 Data Set Introduction
The BOReal Ecosystem-Atmosphere Study (BOREAS) Airborne Fluxes and Meteorology (AFM)-04 team used the National Research Council (NRC) Twin Otter aircraft to make sounding measurements through the boundary layer. These measurements included concentrations of carbon dioxide and ozone, atmospheric pressure, dry bulb temperature, potential temperature, dewpoint temperature, calculated mixing ratio, and wind speed and direction. Aircraft position, heading, and altitude were also recorded. Data were collected at both the Northern Study Area (NSA) and Southern Study Area (SSA) in 1994 and 1996. These data are stored in tabular American Standard Code for Information Interchange (ASCII) files.

1.3 Objective/Purpose

The Twin Otter was one of four flux aircraft operated in BOREAS. The purpose of its sounding flights was to make measurements through the boundary layer to document the vertical structure of the atmosphere over the test area (MacPherson, 1996; MacPherson and Bastian, 1997). The mixed layer was of particular interest in this research.

1.4 Summary of Parameters

Atmospheric pressure, orthogonal components of the wind velocity, wind speed and direction, dry bulb temperature, potential temperature, dewpoint temperature, calculated mixing ratio, carbon dioxide concentration, ozone concentration, aircraft position, heading, altitude (radar and pressure).

1.5 Discussion

The Twin Otter operated in all three Intensive Field Campaigns (IFCs) in 1994 and in July and August 1996. The archived data were collected on sounding runs over the BOREAS site from near the surface to between 6,000 and 8,000 ft (2 and 2.5 km). The Twin Otter flew 51 sounding flights in 1994 and 26 flights in 1996.

1.6 Related Data Sets

BOREAS AFM-01 NOAA/ATDD Long-EZ 1994 Aircraft Flux Data over the SSA
BOREAS AFM-02 Wyoming King Air 1994 Aircraft Flux and Moving Window Data
BOREAS AFM-02 Wyoming King Air 1994 Aircraft Sounding Data
BOREAS AFM-03 NCAR Electra 1994 Aircraft Flux Data
BOREAS AFM-03 NCAR Electra 1994 Aircraft Moving Window Data
BOREAS AFM-03 NCAR Electra 1994 Aircraft Sounding Data
BOREAS AFM-04 NRC Twin Otter Aircraft Flux Data
BOREAS AFM-05 Level-1 Upper Air Network Data
BOREAS AFM-05 Level-2 Upper Air Network Standard Pressure Level Data
BOREAS AFM-11 Aircraft Flux Analysis and Comparison PDF Documents

2. Investigator(s)

2.1 Investigator(s) Name and Title

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2.2 Title of Investigation

Atmospheric Boundary Layer Analyses from Canadian Twin Otter Aircraft

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3. Theory of Measurements

A series of reports addressing the theory and practice of measuring atmospheric variables from a moving, aircraft platform may be found in MacPherson (1988, 1990a, 1990b, 1992, 1996), MacPherson and Morgan (1981), and MacPherson and Bastian (1997).

A basic requirement for measuring gas fluxes from a moving aircraft is to account for the motion of the air relative to the motion of the aircraft. The true air motion is derived from the vector difference between the air velocity relative to the aircraft velocity relative to the ground.

Air motion relative to the aircraft is measured by a nose-mounted gust boom incorporating a Rosemount 858AJ28 5-hole probe. This device and the associated pressure transducers measure static pressure (altitude), dynamic pressure (airspeed), and the angles of attack and sideslip. These instruments in combination with a global positioning system (GPS) and an inertial reference system (IRS) are used to derive the flux measurements.

4. Equipment

4.1 Sensor/Instrument Description

The Twin Otter atmospheric research aircraft is a highly instrumented platform for research on the atmospheric boundary layer, air pollution, etc. Descriptions of the aircraft and its instrumentation and software are given in detail in MacPherson (1988, 1990a, 1990b, 1996), MacPherson and Morgan (1981), and MacPherson and Bastian (1997).

The instruments used to make these measurements included:

Parameter	Instrument
Sensible Heat	Rosemount fast response 102DJ1CG
Incident Solar Radiation	Kipp and Zonen CM-11 pyranometer (305-2800 nm range)
Reflected Solar Radiation	Eppley pyranometer
Greenness Index	Skye Industries Vegetation Greenness Indicator
Surface Temperature	Barnes PRT-5 infrared radiometer
Satellite Simulation	Exotech 100BX Satellite Simulator
CO_2, H_2O	LI-COR LI-6262 CO_2/H_2O analyzer (these CO_2 data reported to BORIS)
	ESRI (developed by Agriculture Canada)
Dew Point	E, G, and G Model 137-S10 Cambridge dew point sensor
Ozone	TECO Ozone Analyzer Model 49 (these O_3 data reported to BORIS)
	GFAS (unit borrowed from German Aerospace Research Establishment)
	Scintrex LOZ-3 ozone detector
Momentum	Wind Components
Inertial Velocity	Litton LTN-90-100 Inertial Reference System
Position	Trimble Model TNL-7880SR GPS/VLF/Omega
Altitude (AGL)	Sperry AA-200 Radio Altimeter (1994 and 1996)
	Riegl LD-90-3 Laser Altimeter (1996 only)

4.1.1 Collection Environment

The data were collected from the aircraft, flying from near the surface to between 6,000 and 8,000 ft (2 and 2.5 km).

4.1.2 Source/Platform
Twin Otter DHC-6-200 twin turboprop utility transport.

The maximum gross takeoff weight is 11,579 lb. The service ceiling is 20,000 ft. The endurance is 3 to 4 hours, depending on instrumentation and weather.

4.1.3 Source/Platform Mission Objectives
The primary objective was to make measurements through the boundary layer to document the vertical structure of the atmosphere over the test area (MacPherson, 1996; MacPherson and Bastian, 1997). The mixed layer was of particular interest in this research.

4.1.4 Key Variables
Atmospheric pressure, orthogonal components of the wind velocity, wind speed and direction, dry bulb temperature, potential temperature, dewpoint temperature, calculated mixing ratio, carbon dioxide concentration, ozone concentration, aircraft position, heading, altitude (radar and pressure).

4.1.5 Principles of Operation
The principles of operation of the aircraft and its instrumentation and software are given in detail in MacPherson (1988, 1990a, 1990b, 1996), MacPherson and Morgan (1981), and MacPherson and Bastian (1997).

4.1.6 Sensor/Instrument Measurement Geometry
See MacPherson (1988, 1990a, 1990b, 1996) and MacPherson and Bastian (1997).

4.1.7 Manufacturer of Sensor/Instrument
See Sections 4.1 and 6, MacPherson (1996), and MacPherson and Bastian (1997).

4.2 Calibration
Instruments on the aircraft were calibrated prior to each IFC. Key instruments (such as temperature probes) were calibrated two or three times during each IFC.

4.2.1 Specifications
Not available at this revision.

4.2.1.1 Tolerance
Not available at this revision.

4.2.2 Frequency of Calibration
All instruments were calibrated at least once per IFC.

4.2.3 Other Calibration Information
See MacPherson (1988, 1990a, 1990b, 1996) and MacPherson and Bastian (1997).

5. Data Acquisition Methods

The data were collected from the aircraft, flying from near the surface to between 6,000 and 8,000 ft (2 and 2.5 km) in a spiral pattern.

6. Observations

6.1 Data Notes

The following is a table that describes how the data were recorded.

Note: 128 channels of data are recorded digitally in 16-bit words at 16 samples per second (1994) or 32 samples per second (1996) on a digital archive tape (DAT) drive. Signals are low-pass filtered with a breakpoint of 5 Hz to prevent aliasing.

The following table lists the 128 recorded signals. Not all of these are archived to BORIS (see Section 8), but many contribute to calculated quantities such as true airspeed (TAS), wind velocity, and fluxes.

Note:* This is basically the recorder buffer to be used in the BOREAS site visit in May 1993. Additional parameters were recorded in BOREAS (e.g., satellite simulator). A Trimble GPS replaced or augmented the Loran-C in 1994.

Channel Number	Variable Name	Units	Resolution (per bit)	Instrument	Description
1	FILEHR	hrs	1	NAE Clock	combined word, tape file and GMT hours
2	MINSEC	min/sec	1	NAE Clock	combined word, GMT minutes/ seconds
3	EVENT	-	1	Event Marker	multi-level event marker
4	LTD	deg	1	ARNAV Loran-C	latitude degrees
5	LTM	min	0.01	Model 40-AVA-100	latitude minutes
6	LGD	deg	1	Model 40-AVA-100	longitude degrees
7	LGM	min	0.01	Model 40-AVA-100	longitude minutes
8	LTML	min	0.01	Litton Inertial Ref System, LTN-90-100	latitude minutes
9	LGML	min	0.01	Litton Inertial Ref System, LTN-90-100	longitude minutes
10	HDGT	deg	0.1	Sperry C-12 Gyro	true heading (magnetic heading corrected to true heading using mag variation output from Loran-C)
11	HDGTL	dec	0.1	Litton 90 IRS	true heading, Litton
12	WDTI	deg	0.1	*Derived*	wind direction from doppler/ inertial system, degrees true (note 1)

Channel Number	Variable Name	Units	Resulution (per bit)	Instrument	Description
13	WDTL	deg	0.1	*Derived*	from Litton system (see note 2)
14	WSMI	m/s	0.01	*Derived*	wind speed from doppler inertial system (note 1)
15	WSML	m/s	0.01	*Derived*	from Litton system (see note 2)
16	UGE	m/s	0.01	*Derived*	north/south wind component from doppler /inertial system, + from north
17	VGE	m/s	0.0	*Derived*	east/west, + from east
18	WGE	m/s	0.0	*Derived*	vertical wind, + up
19	LWN	m/s	0.0	*Derived*	north/south wind component from Litton system, (note 2), + from north
20	LWE	m/s	0.01	*Derived*	east/west wind component, + from east
21	WEP	m/s	0.01	*Derived*	vertical wind component
22	TSNBC	deg C	0.01	*Derived*	static temperature, derived from TAS & total temp (see ch 48) nose starboard temperature probe
23	DEWPTC	deg C	0.01	Egg Model 137	dew point
24	SDCTC	deg C	0.01	*Derived*	static temperature in CO_2 analyzer duct, derived from duct TAS & duct total temp; Rosemount 102 probe
25	PRT5C	deg C	0.01	Barnes PRT-5	surface temperature
26	RADUP	w/m^2	0.1	Kipp & Zonen CM-11	upward facing radiometer, measures incident radiation (see also note 3)
27	RADOWN	w/m^2	0.1	Eppley Pyranometer- 2	downward facing radiometer, measures reflected radiation
28	CO2NO2	mg/m^3	0.1	Ag Canada ESRI CO_2/H_2O Analyzer	carbon dioxide conc, 20 Hz response, low pass filtered at 5.5 Hz for anti-aliasing
29	H2O	g/m^3	0.01	Ag Canada ESRI CO_2/H_2O Analyzer	water vapor conc

Channel Number	Variable Name	Units	Resolution (per bit)	Instrument	Description
30	RALT	m	0.1	Sperry AA-200 Radio Altimeter	height above ground
31	TASFK	kts	0.1	*Derived*	true airspeed, fuselage probes
32	TASNBK	kts	0.1	*Derived*	true airspeed, noseboom probes
33	TASDCT	kts	0.1	*Derived*	true airspeed in CO_2/H_2O analyzer duct
34	PSDUCT	mb	0.1	A.I.R. AIR-DB-2C	static pressure in duct
35	PSNBC	mb	0.1	Paroscientific 215L-AW-01 2	static pressure, noseboom, corrected for position error
36	TSFC	deg C	0.01	*Derived*	static temperature, derived from tas and total temp measured by fuselage port rosemount probe (see channel 47)
37	GRNRAT	-	0.001	Skye Industries SKR-100	greenness ratio, 730 nm signal/660 nm signal
38	VDTM	m/s	0.1	Decca Doppler Radar-72	ground speed, total vector from doppler radar
39	GSL	kts	0.1	Litton 90 IRS	ground speed, total vector from Litton
40	LCCO2	mv	1.0	LI-COR 6262	CO_2 concentration, recorded as millivolts, converted to ppm
41	LCTSC	deg C	0.01	LI-COR 6262	temperature in licor analyzer test cell
42	UGEIL	m/s	0.01	*Derived*	north/south wind component from doppler/Litton system, + from north
43	VGEIL	m/s	0.01	*Derived*	east/west, + from east
44	WGEIL	m/s	0.01	*Derived*	vertical wind, + up
45	LCH2O	mv	1.0	LI-COR 6262	H_2O concentration recored as millivolts, converted to ppt
46	WFIL	m/s	0.01	*Derived*	high-pass filtered vertical wind for eddy accumulation system

Channel Number	Variable Name	Units	Resultion (per bit)	Instrument	Description
47	TTF	deg K	0.01	Rosemount 102DJ1CG	total temperature, fast response, port fuselage probe
48	TTNB	deg K	0.01	Rosemount 102DJ1CG	total temperature, fast response, starboard fuselage probe
49	PSFC	mb	0.1	Rosemount 1201F1B4A1 B	static pressure, fuselage ports, corrected for position error.
50	METHAN	ppb	1.0	Unisearch TDL Methane Analyzer	methane concentration
51	--	--	--	--	not used
52	TECO	ppb	0.1	TECO-49 Ozone Analyzer	ozone concentration, slow response for mean concentrations
53	OZD	ppb	0.1	German GFAS OS-G-2 Ozone Analyzer	ozone concentration fast response (>10 Hz)
54	DOZD	ppb	0.01	German GFAS OS-G-2 Ozone Analyzer	hi-sensitivity ozone fluctuations from start of flux run
55	UCO2N2	mg/m^3	0.1	Ag Canada ESRI CO_2/H_2O Analyzer	raw CO_2 unfiltered
56	UH20N2	g/m^3	0.01	Ag Canada ESRI CO_2/H_2O Analyzer	raw H_2O unfiltered
57	THETAL	deg	0.01	Litton-90 IRS	pitch attitude + nose up
58	PHIL	deg	0.01	Litton-90 IRS	roll attitude + right wing down
59	VXMLTN	m/s	1/128	Decca Doppler Radar-72	along-heading component of ground speed, positive forward, corrected to position of Litton-90 IRS
60	VYMLTN	m/s	1/256	Decca Doppler Radar-72	across-heading component of ground speed, positive starboard, corrected to position of Litton-90 IRS
61	VZMLTN	m/s	1/512	Decca Doppler Radar-72	vertical component of aircraft velocity relative to ground, + down, corrected to position of Litton-90 IRS

Channel Number	Variable Name	Units	Resultion (per bit)	Instrument	Description
62	ULN	m/s	0.01	Litton-90 IRS	north/south inertial velocity, + to north.
63	VLE	m/s	0.0	Litton-90 IRS	east/west inertial velocity, + to east
64	WZL	m/s	0.0	Litton-90 IRS	vertical inertial velocity, + down
65	PDF	mb	0.01	Rosemount Transducer 1221F-2VL7 A1A	dynamic pressure, fuselage pitot uncorrected for p.e.
66	PDNB	mb	0.01	Rosemount Transducer 1221F-1V7A 1B	dynamic pressure, noseboom pitot uncorrected for p.e.
67	PSF	mb	0.10	Rosemount Transducer 1201F-1B4A 1B	static pressure, fuselage ports, uncorrected for p.e.
68	PSNBLR	mb	0.10	Paroscientific 215L-AW-01 2	static pressure, noseboom, corrected to lab standard, uncorrected for p.e.
69	PD	mb	0.01	*Derived*	dynamic pressure used (PDNB or PDF) in real time software selected by function switch
70	PDFNB	mb	0.01	*Derived*	dynamic pressure from fuselage port corrected to noseboom position, used as PDNB backup
71	EACONT	bits	1.0	*Derived*	signal that controls eddy accumulation system,1000 when WFIL is up, -1000 when WFIL is down, zero in dead zone
72	TS	deg C	0.01	*Derived* (TSFC or TSNBC)	static temperature used in real time software, selected by function switch
73	GRN660	-	0.01	Skye Industries SKR-100	660 nm signal from SKR-100 greenness device
74	GRN730	-	0.01	Skye Industries SKR-100	730 nm signal from SKR-100 greenness device
75	TSPARO	deg F	0.01	Paroscientific 215L-AW-01 2	transducer temperature used to correct static pressure signal

Channel Number	Variable Name	Units	Resultion (per bit)	Instrument	Description
76	WGAI	m/s	0.01	*Derived*	vertical wind, doppler system, a/c axes
77	LALT	ft	1.0	Litton 90/100 IRS	absolute height
78	PALT	ft	1.0	*Derived*	pressure height, uses PSNBC
79	LTDL	deg	1.0	Litton 90/100 IRS	Litton latitude, deg only
80	LTDL	deg	1.0	Litton 90/100 IRS	Litton longitude, deg only
81	PDFC	mb	0.01	Rosemount Transducer 1221F-2VL7 A1A	dynamic pressure, fuselage pitot corrected for p.e.
82	PDNBC	mb	0.01	Rosemount Transducer 1221F-1v7a1 b	dynamic pressure, noseboom pitot corrected for p.e.
83	VX	knots	0.10	Decca Doppler Radar-72	ground speed, x component a/c axes, + forward
84	VY	knots	0.10	Decca Doppler Radar-72	ground speed, y component a/c axes, + to starboard
85	VX	knots	0.10	Decca Doppler Radar-72	ground speed, z component a/c axes, + down
86	THETA	deg	0.01	Kearfott Attitude Gyro, T2109	attitude pitch, + nose up
87	PHI	deg	0.01	Kearfott Attitude Gyro, T2109	attitude roll, + right wing down
88	AZL	m/s^2	0.01	Litton 90/100 Irs	vertical acceleration, a/c axes,+ a/c down
89	EAZL	m/s^2	0.01	Litton 90/100 IRS	vertical acceleration earth axes, +a/c down
90	UAIRN	m/s	1/128	*Derived*	north component of true airspeed (TAS) vector
91	VAIRE	m/s	1/128	*Derived*	east component of true airspeed (TAS) vector

Channel Number	Variable Name	Units	Resolution (per bit)	Instrument	Description
92	WAIRZ	m/s	1/128	*Derived*	vertical component of true airspeed (TAS) vector,+ a/c down
93	UAIR	m/s	1/128	*Derived*	x-axis TAS component
94	VAIR	m/s	1/128	*Derived*	y-axis TAS component
95	WAIR	m/s	1/128	*Derived*	z-axis TAS component
96	UANAE	m/s	1/128	*Derived*	x-axis TAS component, corrected to NAE accelerometer location
97	VANAE	m/s	1/128	*Derived*	y-axis TAS component, corrected to NAE accelerometer location
98	WANAE	m/s	1/128	*Derived*	z-axis TAS component, corrected to NAE accelerometer location
99	UALTN	m/s	1/128	*Derived*	x-axis TAS component, corrected to Litton IRS location
100	VALTN	m/s	1/128	*Derived*	y-axis TAS component, corrected to Litton IRS location
101	WALTN	m/s	1/128	*Derived*	z-axis TAS component, corrected to Litton IRS location
102	UMIX7	m/s	1/128	*Derived*	x inertial velocity component from NAE/doppler system
103	VMIX7	m/s	1/128	*Derived*	y inertial velocity component from NAE/doppler system
104	WMIX7	m/s	1/128	*Derived*	z inertial velocity component from NAE/doppler system
105	PDDUCT	mb	0.01	Rosemount Transducer 12211F-2VL7 A1A	dynamic pressure in CO_2 measurement duct
106	ALPHA	deg	0.01	Rosemount 858AJ28 & Transducer 12211F-1VL5 A1	angle of attack probe measured by 5 hole probe on noseboom

Channel Number	Variable Name	Units	Resultion (per bit)	Instrument	Description
107	BETA	deg	0.01	Rosemount 858AJ28 & Transducer 12211F-1VL5 A1	angle of side-probe & slip measured by 5 hole probe on noseboom.
108	UDOTN	m/s^2	1/128	*Derived*	derivative of x inertial velocity from NAE/doppler system
109	VDOTN	m/s^2	1/128	*Derived*	derivative of y inertial velocity from NAE/doppler system
110	WDOTN	m/s^2	1/128	*Derived*	derivative of z inertial velocity from NAE/doppler system
111	UGAI	m/s	0.01	*Derived*	longitudinal wind, doppler system, a/c axes
112	VGAI	m/s	0.01	*Derived*	lateral wind, doppler system, a/c axes
113	PALFNB	mb	0.01	Rosemount Transducer 12211F-1VL5 A1 R-858	differential pressure angle of attack ports
114	UGAIL	m/s	0.01	*Derived*	longitudinal wind, Litton/doppler system, a/c axes
115	VGAIL	m/s	0.01	*Derived*	lateral wind, Litton/doppler system, a/c axes
116	WGAIL	m/s	0.01	*Derived*	vertical wind, Litton/doppler system, a/c axes
117	AXL	m/s^2	0.01	Litton 90/100 IRS	longitudinal acceleration, a/c axes, + a/c fwd
118	AYL	m/s^2	0.01	Litton 90/100 IRS	lateral acceleration, a/c axes, + a/c starboard
119	PBETNB	mb	0.01	Rosemount Transducer 12211F-1VL5A 1 R-858	differential pressure angle of sideslip ports
120	AX	m/s^2	0.01	Systron Donner 4211	longitudinal acceleration, a/c axes, backup system

Channel Number	Variable Name	Units	Resultion (per bit)	Instrument	Description
121	AY	m/s^2	0.01	Systron Donner 4211	lateral acceleration, a/c axes
122	AX	m/s^2	0.01	Systron Donner 4211	vertical acceleration, a/c axes
123	PRATEL	deg/s	0.01	Litton 90/100 IRS	roll rate, + right wing down
124	QRATEL	deg/s	0.01	Litton 90/100 IRS	pitch rate, + nose up
125	RRATEL	deg/s	0.01	Litton 90/100 IRS	yaw rate, + nose right
126	PRATE	deg/s	0.01	Smiths Gyros 402-RGA	roll rate, + right wing down
127	QRATE	deg/s	0.01	Smiths Gyros 402-RGA	pitch rate, + nose up
128	RRATE	deg/s	0.01	Smiths Gyros 402-RGA	yaw rate, + nose right

NOTE 1: This is the backup, or alternative, wind measuring system in case the Litton 90/100 inertial reference system (IRS) should fail. Calculation of wind components is described in reports by MacPherson (1988, 1990a, 1990b, 1996) and MacPherson and Bastian (1997). The air velocity relative to the aircraft is measured by the true air speed (TAS) and noseboom angles of attack and sideslip. The aircraft inertial velocity relative to Earth is measured in aircraft axes by a system incorporating complementary filtering in real time on the aircraft microprocessor. A system of accelerometers and rate gyros provides the high-frequency components to this filter; the Decca 3-axis Doppler radar provides the low-frequency components. The resulting calculated velocity components in a/c axes are subtracted from the TAS components to get the three components of winds in a/c axes. These are then resolved into Earth axes using the pitch and roll attitude and the aircraft heading to get uge, vge, and wge (channels 16-18).

NOTE 2: The primary wind system uses a Litton 90/100 IRS to measure the aircraft inertial velocity components in 3 Earth axes. The IRS is similar to an INS (Inertial Navigation System), but measures the velocities, accelerations and rates in aircraft axes as well as Earth axes. This is also used to derive wind given in channels 11, 13, 15, 19, 20, 21, 42, 43, and 44 above. Numerous tests have been done to compare flux data derived with these two different wind measuring systems on the Twin Otter. Some of this appears in MacPherson (1990a, 1996). These studies reveal that fluxes derived with the older Doppler-based system appear to be underestimated by 10-15 percent. The Litton based wind should be used whenever possible (channels 19, 20, 21, 13, and 15).

6.2 Field Notes
None.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The sounding flights were made centered over a specific point, flying in a spiral pattern, ascending in altitude. The North American Datum of 1983 (NAD83) coordinates for the start and end points for each sounding flight were as follows:

IFC #	Date	Start		End	
		Latitude	Longitude	Latitude	Longitude
IFC-1:	25-May-1994	53.51883N	105.48317W	53.59817N	105.25850W
		53.58183N	106.27834W	53.49650N	106.10700W
	26-May-1994	53.51467N	105.48350W	53.62700N	105.10416W
		53.78517N	104.82267W	53.67783N	105.06850W
	29-May-1994	53.51900N	105.48317W	53.65617N	105.38084W
	01-Jun-1994	53.60417N	106.29400W	53.51883N	106.13850W
	04-Jun-1994	53.62283N	105.20500W	53.76150N	104.87217W
		53.63650N	106.20467W	53.52950N	106.06033W
	07-Jun-1994	55.80250N	98.38917W	55.84517N	98.47000W
	08-Jun-1994	55.79000N	98.41100W	55.88383N	98.82283W
		55.94933N	98.39883W	55.89467N	98.14183W
	09-Jun-1994	55.84883N	98.41950W	55.80550N	98.03200W
	10-Jun-1994	55.79583N	98.41783W	55.77517N	98.56100W
	11-Jun-1994	55.79817N	97.87016W	55.83650N	98.09634W
		55.87500N	98.37517W	55.84083N	98.32350W
	13-Jun-1994	55.95250N	98.39600W	55.93683N	98.24050W
		55.82833N	98.32750W	55.83117N	98.45900W
IFC-2:	20-Jul-1994	53.52433N	105.48083W .	53.59583N	105.28967W
	21-Jul-1994	53.53117N	105.47667W	53.62850N	105.22800W
		53.52850N	105.47933W	53.71933N	105.32267W
	22-Jul-1994	53.63283N	106.18916W	53.54867N	105.91483W

	24-Jul-1994	53.52850N	105.47816W	53.62033N	105.23367W
		53.52417N	105.48217W	53.69150N	105.42416W
	25-Jul-1994	53.52567N	105.48100W	53.61467N	105.17733W
		53.39400N	105.99416W	53.53667N	106.30717W
	26-Jul-1994	53.52800N	105.48083W	53.63300N	105.19083W
	27-Jul-1994	53.52400N	105.48383W	53.54600N	105.75816W
	28-Jul-1994	55.93433N	98.43684W	55.86283N	98.08283W
	29-Jul-1994	55.80000N	97.86333W	55.85450N	98.20634W
	01-Aug-1994	55.78867N	98.41367W	55.94533N	98.94550W
	02-Aug-1994	55.91933N	98.67316W	55.79033N	98.27766W
	04-Aug-1994	55.79433N	98.39983W	55.81483N	98.34267W
	08-Aug-1994	55.90267N	98.31233W	55.92767N	98.24866W
IFC-3:	31-Aug-1994	55.81317N	98.37100W	55.77517N	98.50450W
	02-Sep-1994	55.79716N	97.87117W	55.86967N	98.35633W
	08-Sep-1994	55.92333N	98.66634W	55.92883N	98.41517W
		53.64500N	106.15800W	53.64333N	105.81067W
	11-Sep-1994	53.51900N	105.48233W	53.70433N	105.34650W
		53.49117N	106.00517W	53.53767N	106.28000W
	13-Sep-1994	53.51733N	105.48183W	53.66017N	105.24450W
	14-Sep-1994	53.52167N	105.48050W	53.74967N	105.38450W
		53.93367N	105.35000W	53.90200N	105.37634W
	15-Sep-1994	53.33067N	105.81433W	53.44700N	105.97350W
		53.49133N	105.45050W	53.71200N	105.31883W
	16-Sep-1994	53.52000N	105.48067W	53.65750N	105.01950W
	17-Sep-1994	53.36100N	105.93784W	53.59817N	106.34866W
	18-Sep-1994	53.41450N	106.07133W	53.56283N	106.41734W
		54.95267N	101.96133W	55.88883N	97.99500W
		55.88883N	97.99500W	55.92300N	97.92367W

	19-Sep-1994	55.79833N	98.08283W	55.80353N	98.32050W
		55.89717N	98.27634W	55.87133N	98.02666W
1996:	09-Jul-1996	53.68847N	105.48505W	53.77241N	105.10998W
		53.78666N	104.81798W	53.75954N	105.10448W
		53.42411N	105.93343W	53.62444N	106.19762W
	10-Jul-1996	53.68332N	105.48402W	53.94030N	105.21469W
	11-Jul-1996	53.96244N	104.92509W	53.83380N	105.21297W
	12-Jul-1996	53.68967N	105.48196W	53.83541N	105.29588W
	14-Jul-1996	53.68813N	105.47733W	53.77911N	105.26052W
		53.78923N	105.28061W	53.84983N	105.32730W
	19-Jul-1996	53.45467N	105.96296W	53.54633N	106.19831W
	20-Jul-1996	53.93017N	105.14603W	53.99265N	105.14139W
		53.89687N	105.28954W	53.85172N	105.36043W
		53.85841N	105.40403W	53.77928N	105.37331W
		53.64933N	105.16645W	53.76005N	104.90450W
	26-Jul-1996	53.58015N	106.29976W	53.54736N	106.18561W
	27-Jul-1996	53.91438N	104.97076W	53.89841N	104.92166W
	29-Jul-1996	53.52213N	105.48334W	53.62976N	105.22104W
		53.78666N	104.82622W	53.72709N	104.98947W
		53.48213N	105.91318W	53.65328N	106.13737W
	30-Jul-1996	53.46806N	106.13874W	53.56144N	106.39194W
		54.95413N	101.96686W	54.87190N	101.89870W
		55.87458N	98.37261W	55.88642N	98.19408W
	31-Jul-1996	55.80608N	98.11426W	55.78463N	98.33227W
		55.87921N	98.62667W	55.87870N	98.26447W
		55.77793N	98.41999W	55.80059N	98.19494W

02-Aug-1996	55.79424N	97.88835W	55.80025N	98.15804W
	55.90101N	98.30532W	55.88951N	98.23975W
03-Aug-1996	55.87440N	98.24009W	55.79716N	98.45861W
05-Aug-1996	55.79630N	97.87411W	55.89071N	98.19528W
	55.99354N	98.50307W	55.94582N	98.59818W
	55.91887N	98.63697W	55.85175N	98.41106W
07-Aug-1996	55.79613N	97.87239W	55.81535N	98.11391W
	55.82874N	98.32780W	55.85604N	98.20215W
08-Aug-1996	55.87492N	98.37106W	55.92693N	98.20438W

7.1.2 Spatial Coverage Map
None.

7.1.3 Spatial Resolution
The spatial resolution of the original data used in the flux computations is a function of the aircraft speed (approximately 55 m/s), the digital recording rate (16 Hz in 1994, 32 Hz in 1996), and the anti-alias filtering applied to the data prior to recording (5.5 Hz). This translates to a basic sampling resolution of approximately 12 m (1994) and 6 m (1996) for the Twin Otter.

7.1.4 Projection
These data were collected at point locations.

7.1.5 Grid Description
None.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage
Sounding data were collected from 25-May-1994 to 19-Sep-1994 and 09-Jul-1996 to 08-Aug-1996.

7.2.2 Temporal Coverage Map

IFC-1:	25-May-1994 to 26-May-1994
	29-May-1994
	01-Jun-1994
	04-Jun-1994
	07-Jun-1994 to 11-Jun-1994

	13-Jun-1994
IFC-2:	20-Jul-1994 to 22-Jul-1994
	24-Jul-1994 to 29-Jul-1994
	01-Aug-1994 to 02-Aug-1994
	04-Aug-1994
	08-Aug-1994
IFC-3:	31-Aug-1994
	02-Sep-1994
	08-Sep-1994
	11-Sep-1994 to 19-Sep-1994
1996:	09-Jul-1996 to 12-Jul-1996
	14-Jul-1996
	19-Jul-1996 to 20-Jul-1996
	26-Jul-1996 to 27-Jul-1996
	29-Jul-1996 to 31-Jul-1996
	02-Aug-1996 to 03-Aug-1996
	05-Aug-1996
	07-Aug-1996 to 08-Aug-1996

7.2.3 Temporal Resolution

The aircraft data were recorded at a basic rate of 16 Hz in 1994 and 32 Hz in 1996. Flight durations were typically 3 to 3.5 hours. On several occasions there were two flights per day.

7.3 Data Characteristics

7.3.1 Parameter/Variable

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

```
        Column Name
------------------------------
SPATIAL_COVERAGE
DATE_OBS
TIME
FLUX_MISSION_DESIGNATOR
LATITUDE
LONGITUDE
```

```
BOREAS_X
BOREAS_Y
PRESS_ALT
RADAR_ALT
HEADING
WIND_DIR
WIND_SPEED
U_COMPNT_WIND_VELOC
V_COMPNT_WIND_VELOC
ATMOSPHERIC_PRESS
DRY_BULB_TEMP
POTENT_TEMP
DEWPOINT_TEMP
MIXING_RATIO_AFM
CO2_CONC
O3_CONC
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
SPATIAL_COVERAGE	The general term used to denote the spatial area over which the data were collected.
DATE_OBS	The date on which the data were collected.
TIME	The Greenwich Mean Time (GMT) when the data were collected.
FLUX_MISSION_DESIGNATOR	The two-letter mission identifier used to identify the type of mission being flown, where GS or GN=grids and stacks, CS=Candle Lake runs, TS or TN=site-specific runs, RT=transects, LS or LN=mini- or meso-transects, PS or PN=Budget Box pattern, HS or HN=stacks and tees, FS or FN=flights of two for intercomparison, ZS=low-level routes, and XX=not standard.
LATITUDE	The NAD83-based latitude coordinate at the site.
LONGITUDE	The NAD83-based longitude coordinate at the site.
BOREAS_X	The x component of the BOREAS grid coordinate at the site.
BOREAS_Y	The y component of the BOREAS grid coordinate at the site.
PRESS_ALT	The measured pressure altitude.
RADAR_ALT	The measured radar altitude.
HEADING	The aircraft heading.
WIND_DIR	The direction from which the wind was traveling, increasing in a clockwise direction from north.
WIND_SPEED	The wind speed.
U_COMPNT_WIND_VELOC	The westerly (from the west) vector component of the wind speed and wind direction.
V_COMPNT_WIND_VELOC	The southerly (from the south) vector component of the wind speed and wind direction.

```
ATMOSPHERIC_PRESS              The atmospheric pressure.
DRY_BULB_TEMP                  The temperature measured from the dry-bulb
                              thermometer.
POTENT_TEMP                    The computed potential temperature.
DEWPOINT_TEMP                  The measured dewpoint temperature.
MIXING_RATIO_AFM               The calculated mixing ratio.
CO2_CONC                       CO2 concentration.
O3_CONC                        The measured ozone 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.
```

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
SPATIAL_COVERAGE	[none]
DATE_OBS	[DD-MON-YY]
TIME	[HHMMSS GMT]
FLUX_MISSION_DESIGNATOR	[none]
LATITUDE	[degrees]
LONGITUDE	[degrees]
BOREAS_X	[kilometers]
BOREAS_Y	[kilometers]
PRESS_ALT	[meters]
RADAR_ALT	[meters]
HEADING	[degrees]
WIND_DIR	[degrees]
WIND_SPEED	[meters][second^-1]
U_COMPNT_WIND_VELOC	[meters][second^-1]
V_COMPNT_WIND_VELOC	[meters][second^-1]
ATMOSPHERIC_PRESS	[kiloPascals]
DRY_BULB_TEMP	[degrees Celsius]
POTENT_TEMP	[degrees Kelvin]
DEWPOINT_TEMP	[degrees Celsius]
MIXING_RATIO_AFM	[grams of water vapor][kilogram dry air^-1]
CO2_CONC	[parts per million]
O3_CONC	[parts per billion]
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
-----------------------------------   --------------------------------------------
SPATIAL_COVERAGE                      [Assigned by BORIS.]
DATE_OBS                              [Supplied by AFM-04.]
TIME                                  [Supplied by AFM-04.]
FLUX_MISSION_DESIGNATOR               [Supplied by AFM-04.]
LATITUDE                              [Supplied by AFM-04.]
LONGITUDE                             [Supplied by AFM-04.]
BOREAS_X                              [Supplied by AFM-04.]
BOREAS_Y                              [Supplied by AFM-04.]
PRESS_ALT                            [Supplied by AFM-04.]
RADAR_ALT                            [Supplied by AFM-04.]
HEADING                              [Supplied by AFM-04.]
WIND_DIR                             [Supplied by AFM-04.]
WIND_SPEED                           [Supplied by AFM-04.]
U_COMPNT_WIND_VELOC                  [Supplied by AFM-04.]
V_COMPNT_WIND_VELOC                  [Supplied by AFM-04.]
ATMOSPHERIC_PRESS                    [Supplied by AFM-04.]
DRY_BULB_TEMP                        [Supplied by AFM-04.]
POTENT_TEMP                          [Supplied by AFM-04.]
DEWPOINT_TEMP                        [Supplied by AFM-04.]
MIXING_RATIO_AFM                     [Supplied by AFM-04.]
CO2_CONC                             [Supplied by AFM-04.]
O3_CONC                              [Supplied by AFM-04.]
CRTFCN_CODE                          [Assigned by BORIS.]
REVISION_DATE                        [Assigned by BORIS.]
```

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

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SPATIAL_COVERAGE	N/A	N/A	None	None	None	None
DATE_OBS	25-MAY-94	08-AUG-96	None	None	None	None
TIME	104003	221750	None	None	None	None
FLUX_MISSION_ DESIGNATOR	SN	SN	None	None	None	None
LATITUDE	53.214	56.0225	None	None	None	None
LONGITUDE	-106.4173	-97.86333	-999	None	None	None
BOREAS_X	303.205	817.865	-999	None	None	None
BOREAS_Y	261.727	630.012	-999	None	None	None
PRESS_ALT	224.7	2733.8	None	None	None	None
RADAR_ALT	3.9	920	-999	None	None	None
HEADING	.1	360	None	None	None	None
WIND_DIR	0	360	None	None	None	None
WIND_SPEED	0	23.5	None	None	None	None
U_COMPNT_WIND_VELOC	-9.46	17.18	None	None	None	None
V_COMPNT_WIND_VELOC	-18.05	19.82	None	None	None	None

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```
ATMOSPHERIC_PRESS      72.68           99.41           None    None    None    None
DRY_BULB_TEMP          -4.24           27.85           None    None    None    None
POTENT_TEMP            284.97          308.91          None    None    None    None
DEWPOINT_TEMP          -25.7           16              None    None    None    None
MIXING_RATIO_AFM       .19             13.04           None    None    None    None
CO2_CONC               342.3           427.1           None    None    None    None
O3_CONC                -6.24           196.63          None    None    None    None
CRTFCN_CODE            CPI             CPI             None    None    None    None
REVISION_DATE          12-AUG-96       02-MAR-99       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.

```
SPATIAL_COVERAGE,DATE_OBS,TIME,FLUX_MISSION_DESIGNATOR,LATITUDE,LONGITUDE,
BOREAS_X,BOREAS_Y,PRESS_ALT,RADAR_ALT,HEADING,WIND_DIR,WIND_SPEED,
U_COMPNT_WIND_VELOC,V_COMPNT_WIND_VELOC,ATMOSPHERIC_PRESS,DRY_BULB_TEMP,
POTENT_TEMP,DEWPOINT_TEMP,MIXING_RATIO_AFM,CO2_CONC,O3_CONC,CRTFCN_CODE,
REVISION_DATE
'SSA',25-MAY-94,161831,'SN',53.51883,-105.4832,365.277,294.68,573.4,83.9,6.4,316,
.9,.59,-.63,95.18,15.82,293.09,3.6,5.45,366.3,33.09,'CPI',12-AUG-96
'SSA',25-MAY-94,161832,'SN',53.51983,-105.4832,365.268,294.791,579.1,88.3,8.3,
311,1.3,.95,-.82,95.12,15.8,293.12,3.6,5.45,366.3,33.08,'CPI',12-AUG-96
'SSA',25-MAY-94,161833,'SN',53.52017,-105.4823,365.324,294.833,583.1,93.5,10.6,
295,1.6,1.47,-.69,95.07,15.74,293.1,3.6,5.48,366.3,33.08,'CPI',12-AUG-96
```

8. Data Organization

8.1 Data Granularity
The smallest orderable data set available is one file of flux runs during a day for a given study area.

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
See MacPherson (1990b).

9.1.1 Derivation Techniques and Algorithms
See MacPherson (1990b).
9.2 Data Processing Sequence

9.2.1 Processing Steps
- AFM-04 processed the data and sent them to BORIS.
- BORIS staff received the data, made necessary conversions to standard units, and loaded the data into the data base.
- BORIS staff documented the data set and compiled basic statistics about the data.

See MacPherson (1988, 1990a, 1990b, 1996) and MacPherson and Bastian (1997) for more detailed information about the processing that AFM-04 did to the data before submitting them to BORIS.

9.2.2 Processing Changes
There are quite a number of selectable options in the playback program for the Twin Otter data. These include the option to use the alternative (backup) wind computations if there should be a problem with the Litton 90/100 IRS.

9.3 Calculations

9.3.1 Special Corrections/Adjustments
Calculation of wind components is described in MacPherson (1990b) and MacPherson and Morgan (1981). The air velocity relative to the aircraft is measured by the true airspeed (TAS) and noseboom angles of attack and sideslip. The TAS vector is then resolved into Earth axes (north, east, and vertical components). From these are subtracted the aircraft inertial velocity components measured by a Litton 90/100 IRS, to get the three components of the wind velocity in Earth-fixed axes.

An alternative, or backup, wind system is employed on the Twin Otter in case the Litton 90 is unserviceable (rare). For this system, known as the NAE/DOP winds, the aircraft inertial velocity relative to the Earth is measured in aircraft axes by a system incorporating complementary filtering in real time on the aircraft microprocessor. A system of accelerometers and rate gyros provides the high-frequency components to this filter; the Decca 3-Axis Doppler radar provides the low-frequency components. The resulting calculated velocity components in A/C axes are subtracted from the TAS

components to get the three components of wind in A/C axes. These are then resolved into Earth axes using the pitch, roll, attitude, and heading.

9.3.2 Calculated Variables
None given.

9.4 Graphs and Plots
None.

10. Errors

10.1 Sources of Error
Errors can result from a number of different sources. The flux measurements are subject to possible errors relating to the measurements from the IRS.

A problem was detected with the ESRI CO_2 analyzer. Possible reasons for this problem are listed in MacPherson (1996). As a result of this problem with the ESRI, data from the LI-COR were reported for the CO_2 and H_2O fluxes.

10.2 Quality Assessment

10.2.1 Data Validation by Source
Great care has been taken in the collection and analysis of the Twin Otter data. The wind measuring system is continually monitored for accuracy using techniques such as wind boxes, control input cases, and intercomparisons with other aircraft (Dobosy et al., 1997). Cospectral plots have been used to check the flux contributions at all wavelengths to ensure that they were not contaminated by inadequate compensation for aircraft motion.

Aircraft data were compared at various BOREAS workshops. This led to the decision to include all three sets of fluxes (i.e., from raw, detrended, and high-pass filtered time histories) in the data base.

10.2.2 Confidence Level/Accuracy Judgment
See Section 10.2.1.

10.2.3 Measurement Error for Parameters
Not available at this revision.

10.2.4 Additional Quality Assessments
See Dobosy et al. (1997).

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.

11.4 Other Relevant Information
None.

12. Application of the Data Set

These data can be used to obtain study area and regional scale estimates of the various fluxes.

13. Future Modifications and Plans

None given.

14. Software

14.1 Software Description
None given.

14.2 Software Access
None given.

15. Data Access

The Twin Otter aircraft sounding data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributd Active Archive Center (DAAC).

15.1 Contact Information
For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification
Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/ [Internet Link].

15.3 Procedures for Obtaining Data
Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans
The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and

hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products
Not applicable.

16.2 Film Products
Not applicable.

16.3 Other Products
These data are available on the BOREAS CD-ROM series.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation
The Twin Otter Atmospheric Research Aircraft and its instrumentation have been described in the following reports available from the NRC:

MacPherson, J.I. 1988. NAE Twin Otter Operations in FIFE. National Research Council Canada Report LTR-FR-104.

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17.3 Archive/DBMS Usage Documentation
None.

18. Glossary of Terms

None.

19. List of Acronyms

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AFM      - Airborne Fluxes and Meteorology
AGL      - Above Ground Level
ASCII    - American Standard Code for Information Interchange
BOREAS   - BOReal Ecosystem-Atmosphere Study
BORIS    - BOREAS Information System
CD-ROM   - Compact Disk-Read-Only Memory
DAAC     - Distributed Active Archive Center
DAT      - Digital Archive Tape
EOS      - Earth Observing System
EOSDIS   - EOS Data and Information System
FIFE     - First ISLSCP Field Experiment
FIS      - FIFE Information System
GIS      - Geographic Information System
GMT      - Greenwich Mean Time
GPS      - Global Positioning System
GSFC     - Goddard Space Flight Center
HP       - high pass
HTML     - HyperText Markup Language
IAR      - Institute for Aerospace Research
IFC      - Intensive Field Campaign
INS      - Inertial Navigation System
IRS      - Inertial Reference System
ISLSCP   - International Satellite Land Surface Climatology Project
MSL      - Mean Sea Level
NAD83    - North American Datum of 1983
NAE      - National Aeronautical Establishment
NASA     - National Aeronautics and Space Administration
NCAR     - National Center for Atmospheric Research
NRC      - National Research Council, Canada
NSA      - Northern Study Area
ORNL     - Oak Ridge National Laboratory
PANP     - Prince Albert National Park
RMS      - Root Mean Square
SSA      - Southern Study Area
TAS      - True Air Speed
URL      - Uniform Resource Locator
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13. ABSTRACT (Maximum 200 words)

The BOREAS AFM-4 team used the NRC Twin Otter aircraft to make sounding measurements through the boundary layer. These measurements included concentrations of carbon dioxide and ozone, atmospheric pressure, dry bulb temperature, potential temperature, dewpoint temperature, calculated mixing ratio, and wind speed and direction. Aircraft position, heading, and altitude were also recorded. Data were collected at both the NSA and the SSA in 1994 and 1996. These data are stored in tabular ASCII files.

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