NASA/TM—2000–209891, Vol. 6

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

Forrest G. Hall and David E. Knapp, Editors

Volume 6
BOREAS AFM-04 Twin Otter Aircraft Flux Data

J. I. MacPherson and R.L. Desjardins

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

June 2000

The NASA STI Program Office ... in Profile

Since its founding, NASA has been dedicated to the advancement of aeronautics and space science. The NASA Scientific and Technical Information (STI) Program Office plays a key part in helping NASA maintain this important role.

The NASA STI Program Office is operated by Langley Research Center, the lead center for NASA's scientific and technical information. The NASA STI Program Office provides access to the NASA STI Database, the largest collection of aeronautical and space science STI in the world. The Program Office is also NASA's institutional mechanism for disseminating the results of its research and development activities. These results are published by NASA in the NASA STI Report Series, which includes the following report types:

- TECHNICAL PUBLICATION. Reports of completed research or a major significant phase of research that present the results of NASA programs and include extensive data or theoretical analysis. Includes compilations of significant scientific and technical data and information deemed to be of continuing reference value. NASA's counterpart of peer-reviewed formal professional papers but has less stringent limitations on manuscript length and extent of graphic presentations.
- TECHNICAL MEMORANDUM. Scientific and technical findings that are preliminary or of specialized interest, e.g., quick release reports, working papers, and bibliographies that contain minimal annotation. Does not contain extensive analysis.
- CONTRACTOR REPORT. Scientific and technical findings by NASA-sponsored contractors and grantees.
- CONFERENCE PUBLICATION. Collected papers from scientific and technical conferences, symposia, seminars, or other meetings sponsored or cosponsored by NASA.
- SPECIAL PUBLICATION. Scientific, technical, or historical information from NASA programs, projects, and mission, often concerned with subjects having substantial public interest.
- TECHNICAL TRANSLATION. English-language translations of foreign scientific and technical material pertinent to NASA's mission.

Specialized services that complement the STI Program Office's diverse offerings include creating custom thesauri, building customized databases, organizing and publishing research results . . . even providing videos.

For more information about the NASA STI Program Office, see the following:

- Access the NASA STI Program Home Page at http://www.sti.nasa.gov/STI-homepage.html
- E-mail your question via the Internet to help@sti.nasa.gov
- Fax your question to the NASA Access Help Desk at (301) 621-0134
- Telephone the NASA Access Help Desk at (301) 621-0390
- Write to:
  NASA Access Help Desk
  NASA Center for AeroSpace Information
  7121 Standard Drive
  Hanover, MD 21076-1320

NASA/TM—2000–209891, Vol. 6

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

Forrest G. Hall and David E. Knapp, Editors

Volume 6

BOREAS AFM-04 Twin Otter Aircraft Flux Data

J. Ian MacPherson, Flight Research Laboratory, National Research Council
Raymond L. Desjardins, Centre for Land and Biological Resources Research, Agriculture Canada

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

June 2000

Available from:

NASA Center for AeroSpace Information
7121 Standard Drive
Hanover, MD 21076-1320
Price Code: A17

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Price Code: A10

BOREAS AFM-4 Twin Otter Aircraft Flux Data

J. Ian MacPherson, Raymond L. Desjardins

Summary

The BOREAS AFM-4 team used the NRC Twin Otter aircraft in 1994 and 1996 to make measurements in the boundary layer of the fluxes of sensible and latent heat, momentum, ozone, methane, and carbon dioxide, plus supporting meteorological parameters such as temperature, humidity, and wind speed and direction. Aircraft position, heading, and altitude were also recorded, as were several radiometric observations for use in interpretation of the data (greenness index, surface temperature, incoming and reflected radiation). Data were collected at both the NSA and SSA during the three 1994 IFCs and in July and August of 1996. These data are stored in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS AFM-04 Twin Otter Aircraft Flux 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 in 1994 and 1996 to make measurements in the boundary layer of the fluxes of sensible and latent heat, momentum, ozone, methane, and carbon dioxide, plus supporting meteorological parameters such as temperature, humidity, and wind speed and direction. Aircraft position, heading, and altitude were also recorded, as were several radiometric observations for use in interpretation of the data (greenness index, surface temperature, incoming and reflected radiation). Data were collected at both the Northern Study Area (NSA) and Southern Study Area (SSA) during the three 1994 Intensive Field Campaign (IFCs) and in July and August of 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 flights was to make measurements in the boundary layer of the fluxes of sensible and latent heat, momentum, ozone, methane, and carbon dioxide, plus supporting meteorological parameters such as temperature, humidity, and wind speed and direction. Aircraft position, heading, and altitude were also recorded, as were several radiometric observations for use in interpretation of the data (greenness index, surface temperature, incoming and reflected radiation). These data will be used to attempt to relate boundary layer processes (atmosphere/vegetation exchanges) to radiometric data available from satellites, i.e., ground truthing of satellite data. Through this research, it is hoped that techniques can be developed to utilize satellite data for global monitoring of climate change.

1.4 Summary of Parameters

Temperature, dewpoint temperature, pressure, downwelling radiation, upwelling radiation, greenness index, three orthogonal components of the wind velocity, along-wind component, across wind component, H_2O mixing ratio, CO_2 mixing ratio, ozone concentration, methane, sensible heat flux, latent heat flux, momentum flux, carbon dioxide flux, ozone flux, methane flux, aircraft position, heading, altitude (radar and pressure), surface temperature, satellite simulator.

1.5 Discussion

The Twin Otter operated in all three IFCs in 1994. In 1994 the aircraft made 57 flights, including 1,100 flux runs. In 1996, a total of 27 project flights were made. The recorded data rate was increased from 16 Hz (as in 1994) to 32 Hz (for 1996), improving the resolution of the data contributing to the flux estimates. The archived data were collected on straight and level flux runs over the BOREAS site and on regional runs between Prince Albert and Thompson and in each project area. A variety of flight profiles are possible (grids, L- patterns, profiling stacks, soundings), which are described in Section 7.3. The archive data include run-averaged data, focusing on the fluxes and the supporting meteorological, radiometric, and aircraft positional data. No attempt was made to archive the high-rate (16-Hz or 32-Hz) data, which can be acquired from NRC directly, if required.

There was a significant difference in the instrumentation configuration on the Twin Otter for 1996 when compared with the 1994 campaign. It carried additional cloud physics and aerosol instruments belonging to the Atmospheric Environment Service (AES). These additional data are not included in this data set. Please consult MacPherson (1996) and MacPherson and Bastian (1997) for detailed information about the instrument configurations in 1994 and 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-03 NCAR Electra 1994 Aircraft Flux Data
BOREAS AFM-03 NCAR Electra 1994 Aircraft Moving Window Data
BOREAS AFM-04 NRC Twin Otter Aircraft Sounding 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

J. Ian MacPherson
Flight Research Laboratory Institute for Aerospace Research
National Research Council of Canada
Ottawa, Ontario K1A OR6 Canada

Raymond L. Desjardins
Centre for Land and Biological Resources Research
Agriculture Canada
Building 74
Central Experimental Farm
Ottawa, Ontario K1A 0C6 Canada

2.2 Title of Investigation

Atmospheric Boundary Layer Analyses from Canadian Twin Otter Aircraft

2.3 Contact Information

Contact 1:

J. Ian MacPherson
Bldg. U-61
National Research Council
Ottawa, Ontario
Canada K1A OR6
(613) 998-3014
(613) 952-1704 (fax)
jim@u614ji.iar.nrc.ca

Contact 2:

David Knapp
Raytheon ITSS
NASA GSFC
Code 923.4
Greenbelt, MD 20771
(301) 286-1424
(301) 286-0239 (fax)
David.Knapp@gsfc.nasa.gov

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 (1981, 1988, 1990a, 1990b, 1992, 1996) 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 (1981, 1988, 1990a, 1990b, 1996) and MacPherson and Bastian (1997).

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 at various altitudes.

4.1.2 Source/Platform

Twin Otter DHC-6-200 twin turboprop utility transport.

Maximum gross takeoff weight 11,579 lb. Service ceiling 20,000 ft. Endurance 3 to 4 hours, depending on instrumentation and weather.

4.1.3 Source/Platform Mission Objectives

The primary objective was to measure the vertical flux of sensible and latent heat, CO_2, ozone, methane, and momentum for scaling up surface-based measurements to regional scales. The ultimate objective is to develop algorithms to relate boundary layer processes to satellite-derived data.

4.1.4 Key Variables

Temperature, dewpoint temperature, pressure, downwelling radiation, upwelling radiation, greenness index, three orthogonal components of the wind velocity, along-wind component, across wind component, H_2O mixing ratio, CO_2 mixing ratio, ozone concentration, methane, sensible heat flux, latent heat flux, momentum flux, carbon dioxide flux, ozone flux, methane flux, aircraft position, heading, altitude (radar and pressure), surface temperature, satellite simulator.

4.1.5 Principles of Operation

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.

The principles of operation of the aircraft and its other instrumentation and software are given in detail in MacPherson (1981, 1988, 1990a, 1990b, 1996) 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, and MacPherson (1988, 1990a, 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.

4.2.1.1 Tolerance

Not available.

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

There were several types of flight profiles. These are described in MacPherson (1988, 1990a, 1996) and MacPherson and Bastian (1997). Plotted flight tracks are shown for every flight. One hundred and twenty-eight 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. Most signals are low-pass filtered with a breakpoint of 5 Hz to prevent aliasing.

Fluxes are calculated using the procedures detailed in MacPherson (1990b, 1996) and MacPherson and Bastian (1997). It should be noted that in the final submission to the BORIS, three sets of flux and root mean square (RMS) data were submitted. The first used untreated time histories in the derivation of fluxes using the eddy correlation technique, the second used linearly detrended data, and the third used time histories that were high-pass filtered with a third-order algorithm with a break point set at 0.012 Hz (5 km wavelength). It is felt that most scientists working with these data would prefer to use the linearly detrended data. Data from the National Center for Atmospheric Research (NCAR) and University of Wyoming King Air aircraft were archived with the identical formats.

6. Observations

6.1 Data Notes

None.

6.2 Field Notes

Note: 128 channels of data are recorded digitally in 16-bit words at 16 samples per second on a 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, wind velocity, fluxes, etc.

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

Channel Number	Variable Name	Units	Resultion (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)
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)

Channel Number	Variable Name	Units	Resultion (per bit)	Instrument	Description
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
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
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 positi on 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

Channel Number	Variable Name	Units	Resultion (per bit)	Instrument	Description
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 grnd + down, corrected to position of Litton-90 IRS
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
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

Channel Number	Variable Name	Units	Resultion (per bit)	Instrument	Description
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
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
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

Channel Number	Variable Name	Units	Resultion (per bit)	Instrument	Description
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-1VL5A1 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
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 02-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).

NOTE 3: MacPherson (1988, 1990b, 1996) gives a description of a routine used to correct the radup reading for aircraft attitude changes.

1996 Flights

There may be some steps in some of the analog channels; Most obvious in high-altitude inputs and tests; Required further investigation. It appears that the ESRI and LICOR are slightly motion dependent, producing small additional downward CO_2 flux for ESRI, upward for LICOR.

There is a sawtooth on the WAIRZ that originates from the basic resolution of the digiquartz transducers, PALPHA, PBETA and PDNB. The PDNB is quite steppy when compared with the Rosemount for PDF. The range of the PDNB is too high (0-12 psi, which good for about 700 knots!). It should be replaced with one that does no more than 0-1 psi, or at least that of the PALPHA and PBETA transducers.

Satellite simulator — in MSS mode, 1 deg field of view for Flights 58-62,
in SPOT 15-deg field of view for Flights 63-69
in MSS mode, 15 deg field of view, Flights 70-83

- NOTE: In flux re-analysis with Kalman filtering and ground-calculated winds, the TASNB used in most flights was low by about 0.3 mps. When TASF was used for Flight 65, it was low by 1.3 mps; For Flights 66- when TASF used, then correction factor of 1.3 was applied in airborne program, so no additional adjustment would be required except when working right from pressure data (recalculated in TASFUSE)
- Bias required to beta of +0.35 for all flights except Flt 75, in which it should be 0.54
- TASF will be low by 1.3 mps until Flight 66, for which a bias was added to the airborne program
- TASNB will be low by 0.3 mps until Flight 67, for which a bias was added to the airborne program
- TASNB low by 1.10 mps on Flight 67, possibly due to loose connection on transducer
- For Flight 68 - TAS bias removed from airborne program, but biases added to PDNB of 0.4 mb, and to PDF of 1.2 mb: PDNB bias changed to +0.2 for Flight 69 and subsequent flights
- Temperatures start to diverge about Flight 72, with TSPort greater than starboard, increasing to 1.0 deg by Flight 78.
- NOTE: BOREAS airborne program was inadvertently using old noseboom PE values, not new ones derived on May 16 test flights: In recalculation, run PLOTPOK96_new with correct PE's, then re-run the reciprocal wind checks to get new biases for TAS and Beta. Data suggests that old PE's may be the more accurate. Need to do verification of May 16 PE's on another flight.
- NOTE: Also have noticed that the PDFNB is using the new PE's (0.904*PDFC); To match the old PE's used in the other calculations, 0.936 should be used. Airborne program changed to 0.936 on August 1 before Flight 78
- RADUP reads -6 while in hangar; add bias in REDEF programs
- GPS has lag of several seconds; must adjust in ARCPOK96_new
- TECO possibly reads 3 ppb high; Must check all zeros for each individual flight prior to final archive round of flux calculations.
- NOTE: Greenness index is not necessarily associated with healthy plants and good CO_2 uptake on Ag run, for Canola indicates a greenness index of 1.9, when it is at least as developed as wheat fields giving 3.2-3.5
- LICOR spikes caused by spikes in PSLICOR; affects CO_2 more than H_2O.

The following table indicates instrument status during the flights in 1996.

Date	Flight #	Instrument Status
09-JUL-96	58	• GPS quit twice, first enroute from YPA to W to start Ag run, second in last run of first grid (approx 1755 GMT). Returned to normal at 1808. • LOZ3 ozone analyzer u/s most of flight, turned off for part of flight • NO/NO_2 analyzer reads high throughout flight, although recorded reading is perhaps only a tenth of what was shown on face of unit. • ESRI CO_2/H_2O analyzer intermittent, but H_2O OK after Run 14; CO_2 signal looks OK except for Runs 13 and 14 when unit turned off • Reciprocal runs suggest TAS low by 0.5 mps; apply this bias in re-calc • DLR ozone analyzer has spikes and poor correlation with TECO; Not useable • Laser altimeter drops to below zero in several spikes, perhaps an indication of a signal or error level.
	59	• NO/NO_2 analyzer possibly u/s throughout flight • LOZ3 recycled off/on in sounding (Run 01), but then OK rest of flight; use 1.0 slope when doing fluxes from regression against TECO • Reciprocal runs suggest TASNB low by 0.45 mps
10-JUL-96	60	• GPS quit at 1754 Z for about 4 minutes. Caused abort of Run 13 at OJP • TASNB appears to be low by 0.4 mps • ESRI H_2O signal unusable for Run 09; spikes • NO/NO_2 analyzer not correct, drifting downwards through flight from 20 ppb • Time lost 20 sec at start-up, so IAR time behind AES and cameras by about 20 seconds
11-JUL-96	61	• GPS quit at 1751 for a few minutes • NO/NO_2 analyzer u/s • Time 20 seconds behind cameras, but synchronized with AES DAS • TASNB appears low by about 0.3 mps • Note: CO_2 and H_2O analyzers calibrated prior to this flight • LICOR CO_2 has some spikes and seems noisy and poorly correlated with the ESRI during the OBS runs late in the flight.
12-JUL-96	62	• GPS problem, recycled Off/On at 1745 GMT; Problem identified as poor satellite configuration • DLR ozone analyzer turned off at 1743 due to rain on Run 04 • LOZ3 power supply failed, so unit operated on battery but failed at 1853 Z in Run 11 • ESRI CO_2 should be distrusted on several runs when rain encountered. • NO/NO_2 analyzer removed from aircraft

14-JUL-96	63	• Satellite Simulator changed to SPOT Mode, Gains set at B=5, C=25, and D=5: D is limiting at about 42 W/m^2 only over Ag Run • Flew into rain on Run 10; DLR selected OFF at 1740 • DLR signal alive for first 9 runs, but biased off to near zero concentration for unknown reason • AES DAS quit at 1649 GMT • GPS outage again most of time between 1725 and 1740 GMT • New routine to hold Laser_alt constant when signal drops below zero. Unit does not work over water • Runs 5-11 across Candle Lake include 2 n miles of forest before and after the lake surface, thus the flux calculated over the whole event will not be accurate; Runs must be subdivided to get fluxes for water only. • Good agreement between the ESRI and LICOR CO_2 fluxes, but the LICOR H_2O fluxes quite a bit smaller than the ESRI. • NO/NO_2 analyzer removed from aircraft • Reciprocal Ag runs suggest TASNB too low, as in previous flights.
15-JUL-96	64	• ABORT Flight due to failure of P_Alpha pressure transducer, therefore no vertical gust capability • NO/NO_2 analyzer removed from aircraft

	65	• TEST Flight; Temporary pressure transducer configuration:
		  • P_beta transducer (0-3 PSID) moved to P_alpha position
		  • Noseboom PD transducer (0-12 PSID) moved to P-beta position
		  • NO PDNB or TASNB recorded
		  • Winds and static temperature use TAS_F (i.e., F/S 2 ON)
		  • Alpha and Beta use PDFNB (i.e., F/S 3 ON)
		• TAS_F reads 1.3 mps low
		• Beta bias of -0.4 deg: Add 0.4 deg to beta (which already has an additional 0.35 deg)
		• Greenness Index sensors not turned on
		• NO/NO_2 analyzer removed from aircraft
		• DLR ozone analyzer reads near zero throughout flight
		• Magnetic heading mis-set until 1910.
		• PSNBC incorrect; not corrected for Position Error

19-JUL-96	66	• Pressure transducers back in usual configuration • Beta bias again to add 0.35, and TASNB add 0.3 mps • DLR instrument not flown • NO/NO_2 analyzer removed from aircraft • GPS out at 1715 at end of Run 06 and through Run 07 • First flight with bias of 1.3 mps added to TASF • First flight with Laser altimeter updating at 50 Hz

20-JUL-96	67	• First flight with bias of 0.3 mps added to TASNB • TASNB was low by 1.1 mps, possibly due to loose connection on transducer • Also discovered that airborne program was using old noseboom PE's, rather than new ones derived on May 16 test flight. Will leave that way until end of program • PSduct appears to be 3 mb high. • NO/NO_2 analyzer on aircraft, but NO_2 signal seems highly correlated with altitude.
	68	• For this flight (and subsequent ones), the TAS bias was removed and instead, a bias was added to PDNB (0.4 mb) and PDF (1.2 mb) to bring them to zero while at zero airspeed in the hangar. • Reciprocal data from each grid gives the same TAS error; 0.37 mps should be subtracted from TASNB. Beta bias less than 0.1 deg. • Run 12 was wrong line (FR-FP instead of FR-FQ); Was repeated • GPS locked up on last run of first grid (Run 11); run may have been extended a bit too far east. • GPS out between grids; Poor satellite configuration • PDNBC has little steps that are not identical to PDNB, even on ramp. • Care with fluxes: There are trends and discontinuities in some of the runs for CO_2 and H_2O, perhaps due to large clouds just west of grid.
23-JUL-96	69	• ABORT flight; generator out, then brake fire • PDNB bias set to +0.2 this and subsequent flights; PDF bias remains at +1.2
25-JUL-96	T-11	• GPS not turned on, and heater circuit breakers pulled • Generator failure on takeoff; abort rest of flight • No DAT tape
	T-12	• Generator test: GPS not used; no DAT tape
26-JUL-96	70	• GPS from Convair 580 installed after Flight 69; first project use this flight • GPS intentionally left OFF until after takeoff in case there was a generator problem; selected ON at about 1942Z, a minute after takeoff • Satellite Simulator in MSS Mode, 15 deg, gains 5,5,5,1 • DLR ozone analyzer not installed this flight • PSDUCT checked and found 3 mb high on landing. • Event marker off too short time between Runs 01 and 02: Flux program groups them together, so need to re-run by event time • LICOR H_2O plotted vs ESRI had slope of about 0.85, and resulted in low fluxes compared to ESRI. Prior to this flight, a major calibration was performed on LICOR with many test gases to answer 480 vs 422 problem. No problem was found, but now slope seems low compared to ESRI.

27-JUL-96	71	• GPS intentionally left OFF until after takeoff in case there was a generator problem; selected ON at about 1655Z, a minute after takeoff • DLR ozone analyzer not flown • Runs 20 and 21 through rain shower, may affect ESRI CO_2/H_2O fluxes • Time 20 seconds behind cameras, but aligned with AES DAS • GPS into Standby for about a minute after Ag Run 01 • NB: LICOR H_2O fluxes seemed low compared to ESRI, and even compared to those from DewPt: LICOR H_2O cospectrum has funny shape, with peak at wavelength different from either LICOR CO_2 or ESRI H_2O. • Spikes and/or dropouts in ESRI H_2O signal on at least one run; Must check all runs for H_2O spikes, especially since there is concern about its comparison with the LICOR H_2O.
29-JUL-96	72	• GPS intentionally left OFF until after takeoff in case there was a generator problem; selected ON at about 1513Z, a minute after takeoff • First flight with difference in static pressures; PSNBC greater than PSFC by 1.8 mb; PSFC later proven to be the errant one- Time 20 seconds behind cameras, but synchronized with AES DAS • LICOR H_2O could be low on first 3 or 4 runs • Cospectra indicate that LICOR calibration too low, or ESRI too high • GPS went into Standby at 1720Z at end of Run 18; selected OFF then ON • Spikes in ESRI H_2O signal
	73	• Time 20 seconds behind the cameras, but synchronized with AES DAS • Static pressure difference; PSFC about 2.5 mb too low
30-JUL-96	74	• Time 20 seconds behind the cameras, but synchronized with AES DAS • There is a 2.5 mb difference in PSFC and PSNBC (PSFC probably too low) • GPS went into Standby enroute to 'A'
	75	• Time 20 seconds behind the cameras, but synchronized with AES DAS • There is a 2.5 mb difference in PSFC and PSNBC (PSFC probably too low) • NO/NO_2 device off scale high

31-JUL-96	76	• Time 20 seconds behind the cameras, but synchronized with AES DAS • There is a 2.5 mb difference in PSFC and PSNBC. Ground check August 01 indicate PSFC is errant transducer • NO/NO_2 device off scale high • Standard deviation of ESRI CO_2 signal was high relative to LICOR on several runs, (eg., Run 22); Large spikes in ESRI occasionally, H_2O and CO_2 (Run 5) • LICOR CO_2 signal suspect. seems to lack high frequency, like the H_2O signal of Flight 71. Also, see notes on Flight 77 re: the LICOR CO_2 lag, LICOR span also found low on August 01 calibration • For some reason, the TAS bias has dropped to zero
	77	• Time 20 seconds behind the cameras, but synchronized with AES DAS • There is a 2.5 mb difference in PSFC and PSNBC • NO/NO_2 device off scale high • The difference between the LICOR and ESRI CO_2 fluxes seems larger than usual; check cospectra; LICOR CO_2 has many spikes. Also, Run 02 has positive LICOR CO_2 flux when ESRI negative. Data compared with Harry McCaughey at YJP, LE's agreed, but his CO_2 fluxes agreed well with ESRI (his -0.23, ours ESRI -0.215), and NOT the LICOR (-0.04) • Cospectra show that LICOR CO_2 very suspect (see Run 6); Also, the LICOR CO_2 signal seems to require a different lag than the H_2O, which is very unusual. The CO_2 signal looks like it should have only been lagged 8 time slices, rather than 19 like the H_2O: Found out August 4 that this is due to pressure used in conversion from ppm to concentration. Mixing ratio lags OK • Data archived using ESRI for CO_2 flux, but LICOR for H_2O • When calibrated Aug. 1, the span was low on the LICOR CO_2 by approximately 10 percent. • LICOR Ser. 649 removed from aircraft after this flight and replaced by LICOR Ser. 703 • For some reason, the TAS bias has dropped to zero
01-AUG-96	78	• First flight with LICOR Ser. 703 • LICOR CO_2 fluxes larger, but still well below ESRI • Also, LICOR H_20 fluxes low, particularly on 100' runs; Low at all frequencies, suggesting calibration has low span • Data archived using ESRI for H20 flux, but LICOR for CO_2 • GPS total failure at 1847Z prior to first run • No AES data recorded this flight • There is a 2.5 mb difference in PSFC and PSNBC • PDFNB factor changed to old values of 0.936 PSFC • PSFC less than PDNBC • Port temperature greater than Starboard

02-AUG-96	79	• LICOR fluxes very low compared to ESRI: regression of 32-Hz data suggest calibration sensitivity too low when compared with ESRI. On some runs at YJP, LICOR CO_2 trace very different than ESRI. LICOR CO_2 trace trails ESRI by about 1/2 second, while H_2O is OK. • PSFC less than PDNBC • Port temperature greater than Starboard by about 2 deg C. • Time 20 seconds behind the cameras, but synchronized with AES DAS • Turned ESRI instrument OFF at 1751 after sounding since nitrogen was getting low • DLR ozone analyzer has some large excursions that are not duplicated by LOZ3 or TECO
03-AUG-96	80	• First Flight with LICOR Ser. # 176 (same unit flown in 1994, still using Dec. 1993 calibration constants) • LICOR CO_2 fluxes still well below those of ESRI, and became near zero at end of flight, as in Flight 79 • LICOR H_2O span adjusted in flight right after takeoff; set to approximate data from aircraft dew point sensor. Was reading about 5 gm/Kg high until then (approx. 1610 Z) • PSFC still about 2 mb less than PSNBC • Temperature probes cleaned and recalibrated prior to this flight. • Time 20 seconds behind the cameras, but synchronized with AES DAS • Evidence of steps in most analog channels, most clearly seen in high altitude runs where signals are clean (see pitches)
05-AUG-96	81	• LICOR calibrated before flight; also filter and filter line replaced; old unit had possible small leak at connector • PSFC less than PSNBC by about 2 mb • DLR ozone device matched LOZ3 in flight for first time in quite some time; CWT cleaned unit after last flight • Airborne LICOR subroutine changed before this flight: The CO_2 and H_2O concentrations in mg/m^3 and gm/m^3 respectively are now calculated using the PS_LICOR and LC_TEMP instead of the noseboom pressure and temperature. • Evidence of steps in most analog channels, most clearly seen in high altitude runs where signals are clean (see pitches)
06-AUG-96	T-13	• TEST FLIGHT with ESRI dust closed and 'bagged'; LICOR still plumbed to duct • PSFC lower than PSNBC by about 2 mb • DLR ozone analyzer not installed
07-AUG-96	82	• PSFC lower than PSNBC by about 2 mb • DLR ozone analyzer turned OFF at 1545 Z due to rain • Time about 20 seconds behind camera, but synchronized with AES DAS
08-AUG-96	83	• PSFC lower than PSNBC by about 2 mb • DLR ozone analyzer not flown this flight • Time about 20 seconds behind camera, but synchronized with AES DAS

Summary of 1996 Fluxes

Southern Study Area (SSA)

Date DoY	Flight #	Site	Time [GMT]	Runs #1	Wind [d /mps]	Temp [degC]	H [W /m2]	LE #3 [W /m2]	BR	CO_2 #4 [mg /m2/s]	Oz [ug /m2/s]	NetR [W/m2]
09-Jul-96 191	58	Grid Grid	1730 1845	9 9	197/5.0 198/5.0	19.4 20.0	190 222	208 212	0.91 1.05	-0.39 -0.30	-	679 712
	59	OA	2130	6	182/5.5	20.3	104	270	0.39	-0.73	-0.32	506
10-Jul-96 192	60	OBS OJP	1715 1800	8 7	133/6.0 119/5.2	21.3 22.3	183 224	193 214	0.95 1.05	-0.24 -0.28	-0.31 -0.37	616 644
11-Jul-96 193	61	OA OBS	1715 1845	9 6	012/2.4 036/3.9	20.7 22.3	74 168	313 180	0.23 0.93	-0.81 -0.19	-0.44 -0.10	573 583
14-Jul-96 196	63	Ag Lake	1815 1730	7 7	256/3.8 231/2.5	21.4 20.6	42 1	339 25	0.12 0.06	-0.88 0.00	-0.25 0.00	616 -
19-Jul-96 201	66	OA	1700	6	202/5.6	17.4	120	268	0.45	-0.79	-0.59	615
20-Jul-96 202	67	Lake	1145	6	124/2.0	13.7	7	59	0.12	+0.14	-0.04	-
	68	Grid Grid	1630 1745	9 9	158/3.2 187/2.6	17.5 19.3	152 199	153 247	0.99 0.81	-0.38 -0.39	-0.17 -0.17	557 693
26-Jul-96 208	70	OA	2045	6	165/2.1	18.0	84	215	0.39	-0.82	-0.35	381
27-Jul-96 209	71	Grid Grid OBS	1745 1845 1915	9 9 2	131/3.9 155/4.5 166/4.9	16.9 17.2 17.1	47 42 33	121 #5 125 50	0.39 0.34 0.65	-0.49 6 -0.43 -0.21	-0.34 -0.34 -0.17	311 #6 245 64
29-Jul-96 211	72	OBS Grid Grid	1600 1700 1745	8 9 9	174/1.8 148/1.5 152/1.8	18.6 19.4 20.5	130 134 149	160 187 227	0.82 0.71 0.66	-0.33 -0.37 -0.40	-0.26 -0.24 -0.26	500 578 621
	73	OA	2015	7	177/2.5	22.3	23	173	0.13	-0.43	-0.17	212 #7

#1 - Only nominal 100' runs
#3 - From LICOR
#4 - From LICOR
#5 - LICOR H_2O suspiciously low this day
#6 - Overcast this day
#7 - Clouds over; decreasing radiation study

Note : Fluxes computed with linearly detrended data with Kalman-corrected winds, as archived

Northern Study Area (NSA)

Date DoY	Flight #	Site	Time [GMT]	Runs	Wind [d/mps]	Temp [degC]	H [W /m²]	LE [W /m²]	BR	CO_2 [mg /m²/s]	Oz [ug /m²/s]	NetR [W/m²]
31-Jul-96	76	Grid	1515	9	203/3.6	23.3	92	150	0.61	-0.23	-0.03	450
213		Grid	1615	9	219/4.3	24.3	132	190	0.70	-0.22	-0.09	527
		OBS	1700	5	222/3.9	25.0	196	135	1.45	-0.19	0.01	586
		OJP	1730	8	218/4.3	25.3	237	96	2.46	-0.09	0.00	609
	77	Burn	1915	4	216/5.4	26.1	81	171	0.47	-0.27	-0.20	439
		YJP	1945	8	222/5.0	26.5	175	75	2.32	*#8*	-0.03	368
		Burn	2000	5	212/5.5	26.3	90	211	0.43	-0.22	-0.25	479
										-0.34		
01-Aug-96	78	Burn	1900	4	200/6.4	24.3	64	185	0.35	-0.29	-0.16	317
214								*#9*				
02-Aug-96	79	Grid	1500	9	225/4.6	23.6	62	172	0.36	-0.22	-0.18	431
215		Grid	1600	9	235/5.4	24.8	106	150	0.71	-0.16	-0.16	515
		OBS	1645	5	233/5.7	25.7	148	170	0.87	-0.19	-0.16	599
		OJP	1715	8	228/6.1	26.1	200	83	2.41	-0.07	-0.12	554
		YJP	1745	6	230/7.5	26.4	206	124	1.66	-0.09	-0.10	575
03-Aug-96	80	Grid	1630	9	100/3.5	25.1	135	167	0.81	-0.26	-0.15	509
216		Grid	1730	9	115/3.2	25.9	162	145	1.12	-0.17	-0.16	554
		OBS	1815	6	127/3.5	26.7	205	159	1.28	-0.18	-0.18	591
		YJP	1845	5	104/3.4	27.0	174	67	2.60	-0.02	-0.05	418
05-Aug-96	81	OJP	1600	6	201/3.6	21.6	141	148	0.95	-0.13	-0.21	510
218		Grid	1645	9	195/3.9	22.2	138	222	0.62	-0.27	-0.30	538
		Grid	1745	9	196/4.3	23.1	129	180	0.62	-0.31	-0.17	462
		OJP	1815	6	203/4.4	23.1	68	101	0.67	-0.11	-0.16	182
07-Aug-96	82	OBS	1500	4	295/4.6	12.9	48	143	0.33	-0.29	-0.31	283
220		*#2*	1545	4	280/4.6	13.5	87	190	0.46	-0.36	-0.33	296
		OBS	1645	6	295/6.5	13.6	61	135	0.45	-0.34	-0.17	207 *#10*
		#2										
		Burn										
08-Aug-96	83	Grid	1515	9	004/4.1	9.2	88	88	1.00	-0.43	-0.17	272
221		Grid	1615	9	009/4.0	10.1	144	116	1.24	-0.51	-0.22	400
		OBS	1700	6	014/3.7	11.1	183	136	1.35	-0.50	-0.19	482

#2 - Flux divergence or advection study, only 30 m runs shown
#8 - ESRI CO_2 fluxes used Flt 77
#9 - ESRI LE fluxes used Flt 78
#10 - Increasing cloud

Note : Fluxes computed with linearly detrended data using Kalman-corrected winds: as archived

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

Grid flight patterns consisted of twin sets (one in the NSA and one in the SSA) of nine parallel lines flown at 100 feet above ground level (AGL) at a 2-km spacing covering a 16- by 16-km area. For each of these grids, two flight plans were stored in the aircraft's GPS system; one with the east/west lines, and one with the north/south lines. On a given day, the wind direction was measured and the flight pattern that was closest to cross wind was chosen. Since turbulent eddies are elongated in the direction of the wind, crosswind tracks encounter more eddies; thus, the determination of the flux is statistically more reliable. On each grid flight, the grid pattern was flown twice, with the repeated pass flown in the opposite direction to the first. In this way, each pair of runs on a given line can be examined for possible biases in wind measurement or other variables. The double grid pattern took nearly 2 hours to fly. Some regional runs were also flown, for example, from Prince Albert to Nipawin, Saskatchewan. Very long regional runs were flown (at approximately 500 feet) on the transit flights between Prince Albert (near the SSA) and Thompson (in the NSA).

The two 16-km grids fall within the NSA and SSA. The North American Datum of 1983 (NAD83) corner points for these grid patterns are:

SSA

	Latitude	Longitude
Northeast	53.930° N	104.565° W
Northwest	53.930° N	104.810° W
Southwest	53.787° N	104.810° W
Southeast	53.787° N	104.565° W

NSA

	Latitude	Longitude
Northeast	55.947° N	98.397° W
Northwest	55.947° N	98.653° W
Southwest	55.803° N	98.653° W
Southeast	55.803° N	98.397° W

In their 1996 report, AFM-04 reported the following waypoints for non-grid runs.

	Waypoint 1		Waypoint 2		
Site	Lat.	Long.	Lat.	Long.	Comments
OA - SSA	53 34.9	-106 16.8	53 38.4	-106 09.6	About 11 km, homogeneous vegetation
OBS - SSA	53 59.0	-105 08.2	53 57.8	-104 56.0	14.5 km, mostly spruce, tower near west end
OJP - SSA	53 53.6	-104 44.2	53 56.0	-104 39.5	Only 6 km homog., so marginal for TS
Agricultural Run	53 21.0	-105 28.8	53 31.0	-105 28.9	18.5 km, pasture, canola and wheat
Extended Ag to forest	53 31.0	-105 28.9	53 41.0	-105 29.0	18.5 km interface from Ag to forest
Full Candle Lake Run	53 34.7	-106 23.8	53 59.0	-104 47.2	115 km, Heterogeneous, 3 lakes
Candle Lake Run for morning Flight 67	53 49.8	-105 27.9	53 51.6	-105 12.9	14 km run across Candle lake
OBS - NSA	55 52.5	-98 22.5	55 52.4	-98 34.0	12 km good sfc.
OJP - NSA	55 55.6	-98 37.7	55 56.6	-98 36.2	3 km homog. veg, marginal for TN
Burn - NSA	55 49.7	-98 19.4	55 51.6	-98 30.0	11 km all burned; used for almost all runs in 1994
YJP - NSA	55 53.8	-98 16.4	55 54.2	-98 18.8	< 3km, marginal for flux

Flux runs were also made over Candle Lake over a length of 115 km. These runs were made to cover a heterogeneous track across the study area in order to see how flux varies over different land cover types.

En route from the Prince Albert Airport to the area of the flux towers in the boreal forest, an agricultural area was overflown consisting mostly of pasture, rapeseed, and wheat. To collect data to monitor fluxes over the whole growing season in an agricultural area, a 20-km north/south track was selected in this area. This was flown by the Twin Otter at a 30-m altitude on 40 occasions during the three IFCs in 1994.

On 08-Sept-1994, a 500-km flux run was made along the transect between the NSA and SSA from 1640 to 2040 Greenwich Mean Time (GMT).

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) and 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

None. These data were collected at point locations.

7.1.5 Grid Description

The data were collected at point locations, primarily in a regular grid pattern. The grid spacing was approximately 2 km.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

In 1994, data were collected on the following dates:

```
In 1994, data were collected on the following dates:

IFC-1:  25-May-1994 to 27-May-1994
        29-May-1994
        31-May-1994 to 01-Jun-1994
        04-Jun-1994
        06-Jun-1994 to 11-Jun-1994
        13-Jun-1994

IFC-2:  20-Jul-1994 to 29-Jul-1994
        01-Aug-1994 to 02-Aug-1994
        04-Aug-1994
        08-Aug-1994

IFC-3:  31-Aug-1994 to 03-Sep-1994
        06-Sep-1994
        08-Sep-1994
        11-Sep-1994 to 19-Sep-1994

In 1996, data were collected on the following dates:

        06-Jul-1996 to 07-Jul-1996
        09-Jul-1996 to 12-Jul-1996
        14-Jul-1996 to 15-Jul-1996
        19-Jul-1996 to 20-Jul-1996
        23-Jul-1996
        25-Jul-1996 to 27-Jul-1996
        29-Jul-1996 to 31-Jul-1996
        01-Aug-1996 to 03-Aug-1996
        05-Aug-1996 to 10-Aug-1996
```

SSA * number of runs of each type

Date 1996	Flight	Ag W-X	Intf X-Y	CL	Grid	Specific Site				Flux Budget	Trans	Other	Snd
						OA	BS	JP	Fen				
Jul 09	58	2	2	-	18	-	-	-	-	-	-	-	2
Jul 09	59	-	-	-	-	6	-	-	-	-	-	-	1
Jul 10	60	2	2	-	-	-	8	7	-	-	-	-	1
Jul 11	61	1	1	1	-	9	6	-	-	-	-	-	1
Jul 12	62	2	2	-	-	-	-	-	-	11	-	-	1
Jul 14	63	8	2	-	-	-	-	-	-	-	-	7	2
Jul 15	65	2	-	-	-	-	-	-	-	-	-	-	-
Jul 19	66	-	-	-	-	6	-	-	-	-	-	-	1
Jul 20	67	-	-	-	-	-	2	-	-	-	-	16	3
Jul 20	68	2	-	-	18	-	-	-	-	-	-	-	1
Jul 26	70	1	-	1	-	6	-	-	-	-	-	1	1
Jul 27	71	1	-	-	18	-	2	-	-	-	-	-	1
Jul 29	72	2	-	-	18	-	8	-	-	-	-	-	2
Jul 29	73	1	-	-	-	7	-	-	-	-	-	8	1
Jul 30	74	-	-	1	-	-	-	-	-	-	1	-	2
	17	24	9	3	72	34	26	7	-	11	1	32	20

NSA

Date 1996	Flight	Grid	Specific Site				M-O	Trans	Other	Snd
			burn	BS	OJP	YJP				
Jul 30	75	-	-	6	-	-	1	1	-	1
Jul 31	76	18	-	5	8	-	-	-	2	2
Jul 31	77	-	9	-	-	8	-	-	-	1
Aug 01	78	-	8*	-	-	-	-	-	-	-
Aug 02	79	18	-	5	8	6	-	-	-	2
Aug 03	80	18	-	6	-	5	-	-	4	1
Aug 05	81	18	-	-	12	-	-	-	6	3
Aug 07	82	-	6	12	-	-	-	-	4	2
Aug 08	83	18	-	6	-	-	-	-	-	1
	09	90	23	40	28	19	1	1	16	13

CL: 62 nm Candle Lake
Snd: Sounding
Trans: transect PA/Flin Flon (SSA) Flin Flon/Thompson (NSA)
* 4 runs at 100', 4 at 500'

7.2.2 Temporal Coverage Map

None.

7.2.3 Temporal Resolution

The aircraft data were recorded at a basic rate of 16 Hz (1994) or 32 Hz (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
RUN_START_DATE
RUN_START_TIME
RUN_END_DATE
RUN_END_TIME
FLUX_MISSION_DESIGNATOR
FLUX_MISSION_NUM
FLUX_PASS_NUM
FLUX_SEGMENT_NUM
START_LATITUDE
START_LONGITUDE
END_LATITUDE
END_LONGITUDE
START_BOREAS_X
START_BOREAS_Y
END_BOREAS_X
END_BOREAS_Y
HEADING
MEAN_PRESS_ALTITUDE
MEAN_RADAR_ALTITUDE
MEAN_WIND_DIR
MEAN_WIND_SPEED
MEAN_AIR_TEMP
MEAN_POTNTL_TEMP
MEAN_H2O_MIX_RATIO
MEAN_U_COMPNT_WIND_VELOC
MEAN_V_COMPNT_WIND_VELOC
MEAN_STATIC_PRESS
MEAN_SURF_RAD_TEMP
MEAN_DOWN_TOTAL_RAD
MEAN_UP_TOTAL_RAD
MEAN_DOWN_LONGWAVE_RAD
MEAN_UP_LONGWAVE_RAD
MEAN_NET_RAD
MEAN_UP_PPFD
MEAN_DOWN_PPFD
MEAN_AUX_RAD
MEAN_GREEN_INDEX
MEAN_CO2_CONC
MEAN_O3_CONC
MEAN_CH4_CONC
MEAN_SAT_SIM_CH1
MEAN_SAT_SIM_CH2
MEAN_SAT_SIM_CH3
MEAN_SAT_SIM_CH4
SDEV_AIR_TEMP
SDEV_POTNTL_TEMP
```

SDEV_H2O_MIX_RATIO
SDEV_U_COMPNT_WIND_VELOC
SDEV_V_COMPNT_WIND_VELOC
SDEV_STATIC_PRESS
SDEV_SURF_RAD_TEMP
SDEV_DOWN_TOTAL_RAD
SDEV_UP_TOTAL_RAD
SDEV_DOWN_LONGWAVE_RAD
SDEV_UP_LONGWAVE_RAD
SDEV_NET_RAD
SDEV_UP_PPFD
SDEV_DOWN_PPFD
SDEV_AUX_RAD
SDEV_GREEN_INDEX
SDEV_CO2_CONC
SDEV_O3_CONC
SDEV_CH4_CONC
SDEV_SAT_SIM_CH1
SDEV_SAT_SIM_CH2
SDEV_SAT_SIM_CH3
SDEV_SAT_SIM_CH4
TREND_AIR_TEMP
TREND_POTNTL_TEMP
TREND_H2O_MIX_RATIO
TREND_U_COMPNT_WIND_VELOC
TREND_V_COMPNT_WIND_VELOC
TREND_STATIC_PRESS
TREND_SURF_RAD_TEMP
TREND_DOWN_TOTAL_RAD
TREND_UP_TOTAL_RAD
TREND_DOWN_LONGWAVE_RAD
TREND_UP_LONGWAVE_RAD
TREND_GREEN_INDEX
TREND_CO2_CONC
TREND_O3_CONC
TREND_CH4_CONC
SDEV_VERT_GUST_RAW
SDEV_U_COMPNT_WIND_VELOC_RAW
SDEV_V_COMPNT_WIND_VELOC_RAW
SDEV_ALONG_WIND_RAW
SDEV_CROSS_WIND_RAW
SDEV_POTNTL_TEMP_RAW
SDEV_H2O_MIX_RATIO_RAW
SDEV_CO2_MIX_RATIO_RAW
SDEV_O3_CONC_RAW
SDEV_CH4_CONC_RAW
SKEW_VERT_GUST_RAW
SKEW_U_COMPNT_WIND_VELOC_RAW
SKEW_V_COMPNT_WIND_VELOC_RAW
SKEW_ALONG_WIND_RAW
SKEW_CROSS_WIND_RAW
SKEW_POTNTL_TEMP_RAW
SKEW_H2O_MIX_RATIO_RAW
SKEW_CO2_MIX_RATIO

SKEW_O3_CONC_RAW
SKEW_CH4_CONC_RAW
KURT_VERT_GUST_RAW
KURT_U_COMPNT_WIND_VELOC_RAW
KURT_V_COMPNT_WIND_VELOC_RAW
KURT_ALONG_WIND_RAW
KURT_CROSS_WIND_RAW
KURT_POTNTL_TEMP_RAW
KURT_H2O_MIX_RATIO_RAW
KURT_CO2_MIX_RATIO_RAW
KURT_O3_CONC_RAW
KURT_CH4_CONC_RAW
CORC_VERT_U_WIND_COMPNT_RAW
CORC_VERT_V_WIND_COMPNT_RAW
CORC_VERT_ALONG_WIND_RAW
CORC_VERT_CROSS_WIND_RAW
CORC_VERT_POTNTL_TEMP_RAW
CORC_VERT_H2O_MIX_RATIO_RAW
CORC_VERT_CO2_MIX_RATIO_RAW
CORC_VERT_O3_CONC_RAW
CORC_VERT_CH4_CONC_RAW
CORC_POTNTL_H2O_MIX_RATIO_RAW
MMNTM_FLUX_V_WIND_COMPNT_RAW
MMNTM_FLUX_U_WIND_COMPNT_RAW
MMNTM_FLUX_ALONG_MEAN_WIND_RAW
MMNTM_FLUX_CROSS_MEAN_WIND_RAW
SENSIBLE_HEAT_FLUX_RAW
LATENT_HEAT_FLUX_RAW
CO2_FLUX_RAW
O3_FLUX_RAW
O3_DEPOSITION_VELOC_RAW
CH4_FLUX_RAW
AIR_DENSITY_CONSTANT
SPECIFIC_HEAT_CONSTANT
LATENT_HEAT_VAP_CONSTANT
DRY_AIR_GAS_CONSTANT
SDEV_VERT_GUST_DET
SDEV_U_COMPNT_WIND_VELOC_DET
SDEV_V_COMPNT_WIND_VELOC_DET
SDEV_ALONG_WIND_DET
SDEV_CROSS_WIND_DET
SDEV_POTNTL_TEMP_DET
SDEV_H2O_MIX_RATIO_DET
SDEV_CO2_MIX_RATIO
SDEV_O3_CONC_DET
SDEV_CH4_CONC_DET
SKEW_VERT_GUST_DET
SKEW_U_COMPNT_WIND_VELOC_DET
SKEW_V_COMPNT_WIND_VELOC_DET
SKEW_ALONG_WIND_DET
SKEW_CROSS_WIND_DET
SKEW_POTNTL_TEMP_DET
SKEW_H2O_MIX_RATIO_DET
SKEW_CO2_MIX_RATIO_DET

SKEW_O3_CONC_DET
SKEW_CH4_CONC_DET
KURT_VERT_GUST_DET
KURT_U_COMPNT_WIND_VELOC_DET
KURT_V_COMPNT_WIND_VELOC_DET
KURT_ALONG_WIND_DET
KURT_CROSS_WIND_DET
KURT_POTNTL_TEMP_DET
KURT_H2O_MIX_RATIO_DET
KURT_CO2_MIX_RATIO_DET
KURT_O3_CONC_DET
KURT_CH4_CONC_DET
CORC_VERT_U_WIND_COMPNT_DET
CORC_VERT_V_WIND_COMPNT_DET
CORC_VERT_ALONG_WIND_DET
CORC_VERT_CROSS_WIND_DET
CORC_VERT_POTNTL_TEMP_DET
CORC_VERT_H2O_MIX_RATIO_DET
CORC_VERT_CO2_MIX_RATIO_DET
CORC_VERT_O3_CONC_DET
CORC_VERT_CH4_CONC_DET
CORC_POTNTL_H2O_MIX_RATIO_DET
MMNTM_FLUX_U_WIND_COMPNT_DET
MMNTM_FLUX_V_WIND_COMPNT_DET
MMNTM_FLUX_ALONG_MEAN_WIND_DET
MMNTM_FLUX_CROSS_MEAN_WIND_DET
SENSIBLE_HEAT_FLUX_DET
LATENT_HEAT_FLUX_DET
CO2_FLUX_DET
O3_FLUX_DET
O3_DEPOSITION_VELOC_DET
CH4_FLUX_DET
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.
RUN_START_DATE	The date in GMT at the beginning of the segment (or pass if not segmented) in the form DD-MON-YY.
RUN_START_TIME	The time in GMT at the beginning of the segment (or pass if not segmented).
RUN_END_DATE	The date in GMT at the end of the segment (or pass if not segmented) in the form DD-MON-YY.
RUN_END_TIME	The time in GMT at the end of the segment (or pass if not segmented).
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.
FLUX_MISSION_NUM	The sequential number for all missions flown on a given day starting at 1.
FLUX_PASS_NUM	The sequential pass number within a mission starting at 1.
FLUX_SEGMENT_NUM	The segment number within the current pass starting at 1 or given as 0 if pass is not segmented.
START_LATITUDE	The NAD83 based latitude coordinate at the start of the measurement set.
START_LONGITUDE	The NAD83 based longitude coordinate at the start of the measurement set.
END_LATITUDE	The NAD83 based latitude coordinate at the end of the measurement set.
END_LONGITUDE	The NAD83 based longitude coordinate at the end of the measurement set.
START_BOREAS_X	The x component of the BOREAS grid coordinate at the start of the measurement set.
START_BOREAS_Y	The y component of the BOREAS grid coordinate at the start of the measurement set.
END_BOREAS_X	The x component of the BOREAS grid coordinate at the end of the measurement set.
END_BOREAS_Y	The y component of the BOREAS grid coordinate at the end of the measurement set.
HEADING	The aircraft heading.
MEAN_PRESS_ALTITUDE	The mean pressure altitude.
MEAN_RADAR_ALTITUDE	The mean radar altitude.
MEAN_WIND_DIR	The mean direction from which the wind was traveling, increasing in a clockwise direction from the north for the given time over the period defined by the start and end dates.
MEAN_WIND_SPEED	The mean wind speed for the given time over the period defined by the start and end dates.
MEAN_AIR_TEMP	The mean air temperature.
MEAN_POTNTL_TEMP	The mean potential temperature.
MEAN_H2O_MIX_RATIO	The mean water vapor mixing ratio.
MEAN_U_COMPNT_WIND_VELOC	The mean westerly vector component of the wind speed and wind direction.
MEAN_V_COMPNT_WIND_VELOC	The mean southerly vector component of the wind speed and wind direction.
MEAN_STATIC_PRESS	The mean static pressure.
MEAN_SURF_RAD_TEMP	The mean surface radiative temperature.
MEAN_DOWN_TOTAL_RAD	The mean downwelling total radiation.
MEAN_UP_TOTAL_RAD	The mean upwelling total radiation.
MEAN_DOWN_LONGWAVE_RAD	The mean downward longwave radiation.
MEAN_UP_LONGWAVE_RAD	The mean upwelling longwave radiation.
MEAN_NET_RAD	The mean net radiation.
MEAN_UP_PPFD	The mean upward photosynthetic photon flux density.
MEAN_DOWN_PPFD	The mean downward photosynthetic photon flux

	density.
MEAN_AUX_RAD	The mean measurement from the auxiliary radiation sensor.
MEAN_GREEN_INDEX	The mean greenness index.
MEAN_CO2_CONC	The mean carbon dioxide concentration.
MEAN_O3_CONC	The mean ozone concentration.
MEAN_CH4_CONC	The mean methane concentration.
MEAN_SAT_SIM_CH1	The mean channel 1 satellite simulator.
MEAN_SAT_SIM_CH2	The mean channel 2 satellite simulator.
MEAN_SAT_SIM_CH3	The mean channel 3 satellite simulator.
MEAN_SAT_SIM_CH4	The mean channel 4 satellite simulator.
SDEV_AIR_TEMP	The standard deviation of the air temperature.
SDEV_POTNTL_TEMP	The standard deviation of potential temperature.
SDEV_H2O_MIX_RATIO	The standard deviation of the water vapor mixing ratio.
SDEV_U_COMPNT_WIND_VELOC	The standard deviation of the westerly vector component of the wind speed and wind direction.
SDEV_V_COMPNT_WIND_VELOC	The standard deviation of the southerly vector component of the wind speed and wind direction.
SDEV_STATIC_PRESS	The standard deviation of the static pressure.
SDEV_SURF_RAD_TEMP	The standard deviation of the surface radiative temperature.
SDEV_DOWN_TOTAL_RAD	The standard deviation of downwelling total radiation.
SDEV_UP_TOTAL_RAD	The standard deviation of upwelling total radiation.
SDEV_DOWN_LONGWAVE_RAD	The standard deviation of the downward longwave radiation.
SDEV_UP_LONGWAVE_RAD	The standard deviation of upwelling longwave radiation.
SDEV_NET_RAD	The standard deviation of the mean net radiation.
SDEV_UP_PPFD	The standard deviation of the upward photosynthetic photon flux density.
SDEV_DOWN_PPFD	The standard deviation of the downward photosynthetic photon flux density.
SDEV_AUX_RAD	The standard deviation of the measurements from the auxiliary radiation sensor.
SDEV_GREEN_INDEX	The standard deviation of greenness index.
SDEV_CO2_CONC	The standard deviation of the CO2 concentration.
SDEV_O3_CONC	The standard deviation of the ozone concentration.
SDEV_CH4_CONC	The standard deviation of CH4 concentration.
SDEV_SAT_SIM_CH1	The standard deviation of the channel 1 satellite simulator values.
SDEV_SAT_SIM_CH2	The standard deviation of channel 2 satellite simulator values.
SDEV_SAT_SIM_CH3	The standard deviation of channel 3 satellite simulator values.
SDEV_SAT_SIM_CH4	The standard deviation of channel 4 satellite simulator values.
TREND_AIR_TEMP	The trend in air temperature.
TREND_POTNTL_TEMP	The trend in potential temperature.
TREND_H2O_MIX_RATIO	The trend in water vapor mixing ratio.
TREND_U_COMPNT_WIND_VELOC	The trend in the westerly vector component of

	the wind speed and wind direction.
TREND_V_COMPNT_WIND_VELOC	The trend in the southerly vector component of the wind speed and wind direction.
TREND_STATIC_PRESS	The trend in static pressure.
TREND_SURF_RAD_TEMP	The trend in surface radiative temperature.
TREND_DOWN_TOTAL_RAD	The trend in the downwelling total radiation.
TREND_UP_TOTAL_RAD	The trend in the upwelling total radiation.
TREND_DOWN_LONGWAVE_RAD	The trend in the downwelling longwave radiation.
TREND_UP_LONGWAVE_RAD	The trend in the upwelling longwave radiation.
TREND_GREEN_INDEX	The trend in the greenness index.
TREND_CO2_CONC	The trend in the carbon dioxide concentration.
TREND_O3_CONC	The trend in the ozone concentration.
TREND_CH4_CONC	The trend in the methane concentration.
SDEV_VERT_GUST_RAW	The standard deviation of the raw vertical gust.
SDEV_U_COMPNT_WIND_VELOC_RAW	The standard deviation of the raw westerly wind component.
SDEV_V_COMPNT_WIND_VELOC_RAW	The standard deviation of the raw southerly wind component.
SDEV_ALONG_WIND_RAW	The standard deviation of the raw along wind component.
SDEV_CROSS_WIND_RAW	The standard deviation of the raw cross wind component.
SDEV_POTNTL_TEMP_RAW	The standard deviation of the raw potential temperature.
SDEV_H2O_MIX_RATIO_RAW	The standard deviation of the raw water vapor mixing ratio.
SDEV_CO2_MIX_RATIO_RAW	The standard deviation of the raw carbon dioxide mixing ratio.
SDEV_O3_CONC_RAW	The standard deviation of the raw ozone concentration.
SDEV_CH4_CONC_RAW	The standard deviation of the raw methane concentration.
SKEW_VERT_GUST_RAW	The skewness of the raw vertical gust.
SKEW_U_COMPNT_WIND_VELOC_RAW	The skewness of the raw westerly wind component.
SKEW_V_COMPNT_WIND_VELOC_RAW	The skewness of the raw southerly wind component.
SKEW_ALONG_WIND_RAW	The skewness of the raw along wind component.
SKEW_CROSS_WIND_RAW	The skewness of the raw cross wind component.
SKEW_POTNTL_TEMP_RAW	The skewness of the raw potential temperature.
SKEW_H2O_MIX_RATIO_RAW	The skewness of the raw water vapor mixing ratio.
SKEW_CO2_MIX_RATIO	The skewness of the raw carbon dioxide mixing ratio.
SKEW_O3_CONC_RAW	The skewness of the raw ozone concentration.
SKEW_CH4_CONC_RAW	The skewness of the raw methane concentration.
KURT_VERT_GUST_RAW	The kurtosis of the raw vertical gust.
KURT_U_COMPNT_WIND_VELOC_RAW	The kurtosis of the raw westerly wind component.
KURT_V_COMPNT_WIND_VELOC_RAW	The kurtosis of the raw southerly wind component.
KURT_ALONG_WIND_RAW	The kurtosis of the raw along wind component.
KURT_CROSS_WIND_RAW	The kurtosis of the raw cross wind component.
KURT_POTNTL_TEMP_RAW	The kurtosis of the raw potential temperature.
KURT_H2O_MIX_RATIO_RAW	The kurtosis of the raw water vapor mixing ratio.
KURT_CO2_MIX_RATIO_RAW	The kurtosis of the raw carbon dioxide mixing ratio.
KURT_O3_CONC_RAW	The kurtosis of the raw ozone concentration.
KURT_CH4_CONC_RAW	The kurtosis of the raw methane concentration.

CORC_VERT_U_WIND_COMPNT_RAW	The correlation coefficient of the raw vertical gust/westerly wind component pair.
CORC_VERT_V_WIND_COMPNT_RAW	The correlation coefficient of the raw vertical gust/southerly wind component pair.
CORC_VERT_ALONG_WIND_RAW	The correlation coefficient of the raw vertical gust/along wind component pair.
CORC_VERT_CROSS_WIND_RAW	The correlation coefficient of the raw vertical gust/cross wind component pair.
CORC_VERT_POTNTL_TEMP_RAW	The correlation coefficient of the raw vertical gust/potential temperature pair.
CORC_VERT_H2O_MIX_RATIO_RAW	The correlation coefficient of the raw vertical gust/water vapor mixing ratio pair.
CORC_VERT_CO2_MIX_RATIO_RAW	The correlation coefficient of the raw vertical gust/carbon dioxide mixing ratio pair.
CORC_VERT_O3_CONC_RAW	The correlation coefficient of the raw vertical gust/ozone concentration pair.
CORC_VERT_CH4_CONC_RAW	The correlation coefficient of the vertical gust /methane concentration pair.
CORC_POTNTL_H2O_MIX_RATIO_RAW	The correlation coefficient of the raw potential temperature/water vapor mixing ratio pair.
MMNTM_FLUX_V_WIND_COMPNT_RAW	The momentum flux using the raw southerly wind component.
MMNTM_FLUX_U_WIND_COMPNT_RAW	The momentum flux using the raw westerly wind component.
MMNTM_FLUX_ALONG_MEAN_WIND_RAW	The momentum flux using the raw along mean wind component.
MMNTM_FLUX_CROSS_MEAN_WIND_RAW	The momentum flux using the raw across mean wind component.
SENSIBLE_HEAT_FLUX_RAW	The raw sensible heat flux.
LATENT_HEAT_FLUX_RAW	The raw latent heat flux.
CO2_FLUX_RAW	The raw carbon dioxide flux.
O3_FLUX_RAW	The raw ozone flux.
O3_DEPOSITION_VELOC_RAW	The raw ozone deposition velocity.
CH4_FLUX_RAW	The raw methane flux.
AIR_DENSITY_CONSTANT	The constant used for air density in the flux calculations.
SPECIFIC_HEAT_CONSTANT	The constant used for specific heat at constant pressure in the flux calculations.
LATENT_HEAT_VAP_CONSTANT	The constant used for latent heat of vaporization in the flux calculations.
DRY_AIR_GAS_CONSTANT	The dry air gas constant used in the flux calculations.
SDEV_VERT_GUST_DET	The standard deviation of the detrended vertical gust.
SDEV_U_COMPNT_WIND_VELOC_DET	The standard deviation of the detrended westerly wind component.
SDEV_V_COMPNT_WIND_VELOC_DET	The standard deviation of the detrended southerly wind component.
SDEV_ALONG_WIND_DET	The standard deviation of the detrended along wind component.
SDEV_CROSS_WIND_DET	The standard deviation of the detrended cross wind component.
SDEV_POTNTL_TEMP_DET	The standard deviation of the detrended potential temperature.

SDEV_H2O_MIX_RATIO_DET	The standard deviation of the detrended water vapor mixing ratio.
SDEV_CO2_MIX_RATIO	The standard deviation of the detrended carbon dioxide mixing ratio.
SDEV_O3_CONC_DET	The standard deviation of the detrended ozone concentration.
SDEV_CH4_CONC_DET	The standard deviation of the detrended methane concentration.
SKEW_VERT_GUST_DET	The skewness of the detrended vertical gust.
SKEW_U_COMPNT_WIND_VELOC_DET	The skewness of the detrended westerly wind component.
SKEW_V_COMPNT_WIND_VELOC_DET	The skewness of the detrended southerly wind component.
SKEW_ALONG_WIND_DET	The skewness of the detrended along wind component.
SKEW_CROSS_WIND_DET	The skewness of the detrended cross wind component.
SKEW_POTNTL_TEMP_DET	The skewness of the detrended potential temperature.
SKEW_H2O_MIX_RATIO_DET	The skewness of the detrended water vapor mixing ratio.
SKEW_CO2_MIX_RATIO_DET	The skewness of the detrended carbon dioxide mixing ratio.
SKEW_O3_CONC_DET	The skewness of the detrended ozone concentration.
SKEW_CH4_CONC_DET	The skewness of the detrended methane concentration.
KURT_VERT_GUST_DET	The kurtosis of the detrended vertical gust.
KURT_U_COMPNT_WIND_VELOC_DET	The kurtosis of the detrended westerly wind component.
KURT_V_COMPNT_WIND_VELOC_DET	The kurtosis of the detrended southerly wind component.
KURT_ALONG_WIND_DET	The kurtosis of the detrended along wind component.
KURT_CROSS_WIND_DET	The kurtosis of the detrended cross wind component.
KURT_POTNTL_TEMP_DET	The kurtosis of the detrended potential temperature.
KURT_H2O_MIX_RATIO_DET	The kurtosis of the detrended water vapor mixing ratio.
KURT_CO2_MIX_RATIO_DET	The kurtosis of the detrended carbon dioxide mixing ratio.
KURT_O3_CONC_DET	The kurtosis of the detrended ozone concentration.
KURT_CH4_CONC_DET	The kurtosis of the detrended methane concentration.
CORC_VERT_U_WIND_COMPNT_DET	The correlation coefficient of the detrended vertical gust/westerly wind component pair.
CORC_VERT_V_WIND_COMPNT_DET	The correlation coefficient of the detrended vertical gust/southerly wind component pair.
CORC_VERT_ALONG_WIND_DET	The correlation coefficient of the detrended vertical gust/along wind component pair.
CORC_VERT_CROSS_WIND_DET	The correlation coefficient of the detrended vertical gust/cross wind component pair.

CORC_VERT_POTNTL_TEMP_DET	The correlation coefficient of the detrended vertical gust/potential temperature pair.
CORC_VERT_H2O_MIX_RATIO_DET	The correlation coefficient of the detrended vertical gust/water vapor mixing ratio pair.
CORC_VERT_CO2_MIX_RATIO_DET	The correlation coefficient of the detrended vertical gust/carbon dioxide mixing ratio pair.
CORC_VERT_O3_CONC_DET	The correlation coefficient of the detrended vertical gust/ozone concentration pair.
CORC_VERT_CH4_CONC_DET	The correlation coefficient of the detrended vertical gust/methane concentration pair.
CORC_POTNTL_H2O_MIX_RATIO_DET	The correlation coefficient of the detrended potential temperature/water vapor mixing ratio pair.
MMNTM_FLUX_U_WIND_COMPNT_DET	The momentum flux using the detrended westerly wind component.
MMNTM_FLUX_V_WIND_COMPNT_DET	The momentum flux using the detrended southerly wind component.
MMNTM_FLUX_ALONG_MEAN_WIND_DET	The momentum flux using the detrended along mean wind component.
MMNTM_FLUX_CROSS_MEAN_WIND_DET	The momentum flux using the detrended across mean wind component.
SENSIBLE_HEAT_FLUX_DET	The detrended sensible heat flux.
LATENT_HEAT_FLUX_DET	The detrended latent heat flux.
CO2_FLUX_DET	The detrended carbon dioxide flux.
O3_FLUX_DET	The detrended ozone flux.
O3_DEPOSITION_VELOC_DET	The detrended ozone deposition velocity.
CH4_FLUX_DET	The detrended methane flux.
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]
RUN_START_DATE	[DD-MON-YY]
RUN_START_TIME	[HHMMSS GMT]
RUN_END_DATE	[DD-MON-YY]
RUN_END_TIME	[HHMMSS GMT]
FLUX_MISSION_DESIGNATOR	[none]
FLUX_MISSION_NUM	[unitless]
FLUX_PASS_NUM	[unitless]
FLUX_SEGMENT_NUM	[unitless]
START_LATITUDE	[degrees]
START_LONGITUDE	[degrees]
END_LATITUDE	[degrees]
END_LONGITUDE	[degrees]
START_BOREAS_X	[kilometers]
START_BOREAS_Y	[kilometers]

END_BOREAS_X	[kilometers]
END_BOREAS_Y	[kilometers]
HEADING	[degrees]
MEAN_PRESS_ALTITUDE	[meters]
MEAN_RADAR_ALTITUDE	[meters]
MEAN_WIND_DIR	[degrees]
MEAN_WIND_SPEED	[meters][second^-1]
MEAN_AIR_TEMP	[degrees Celsius]
MEAN_POTNTL_TEMP	[degrees Kelvin]
MEAN_H2O_MIX_RATIO	[grams of water vapor][kilogram dry air^-1]
MEAN_U_COMPNT_WIND_VELOC	[meters][second^-1]
MEAN_V_COMPNT_WIND_VELOC	[meters][second^-1]
MEAN_STATIC_PRESS	[kiloPascals]
MEAN_SURF_RAD_TEMP	[degrees Celsius]
MEAN_DOWN_TOTAL_RAD	[Watts][meter^-2]
MEAN_UP_TOTAL_RAD	[Watts][meter^-2]
MEAN_DOWN_LONGWAVE_RAD	[Watts][meter^-2]
MEAN_UP_LONGWAVE_RAD	[Watts][meter^-2]
MEAN_NET_RAD	[Watts][meter^-2]
MEAN_UP_PPFD	[microEinsteins][meter^-2][second^-1]
MEAN_DOWN_PPFD	[microEinsteins][meter^-2][second^-1]
MEAN_AUX_RAD	[Watts][meter^-2]
MEAN_GREEN_INDEX	[unitless]
MEAN_CO2_CONC	[micromoles CO2][mole air^-1]
MEAN_O3_CONC	[nanomoles O3][mole air^-1]
MEAN_CH4_CONC	[nanomoles CH4][mole air^-1]
MEAN_SAT_SIM_CH1	[unitless]
MEAN_SAT_SIM_CH2	[unitless]
MEAN_SAT_SIM_CH3	[unitless]
MEAN_SAT_SIM_CH4	[unitless]
SDEV_AIR_TEMP	[degrees Celsius]
SDEV_POTNTL_TEMP	[degrees Kelvin]
SDEV_H2O_MIX_RATIO	[grams of water vapor][kilogram dry air^-1]
SDEV_U_COMPNT_WIND_VELOC	[meters][second^-1]
SDEV_V_COMPNT_WIND_VELOC	[meters][second^-1]
SDEV_STATIC_PRESS	[kiloPascals]
SDEV_SURF_RAD_TEMP	[degrees Celsius]
SDEV_DOWN_TOTAL_RAD	[Watts][meter^-2]
SDEV_UP_TOTAL_RAD	[Watts][meter^-2]
SDEV_DOWN_LONGWAVE_RAD	[Watts][meter^-2]
SDEV_UP_LONGWAVE_RAD	[Watts][meter^-2]
SDEV_NET_RAD	[Watts][meter^-2]
SDEV_UP_PPFD	[microEinsteins][meter^-2][second^-1]
SDEV_DOWN_PPFD	[microEinsteins][meter^-2][second^-1]
SDEV_AUX_RAD	[unitless]
SDEV_GREEN_INDEX	[unitless]
SDEV_CO2_CONC	[micromoles CO2][mole air^-1]
SDEV_O3_CONC	[nanomoles O3][mole air^-1]
SDEV_CH4_CONC	[nanomoles CH4][mole air^-1]
SDEV_SAT_SIM_CH1	[unitless]
SDEV_SAT_SIM_CH2	[unitless]
SDEV_SAT_SIM_CH3	[unitless]
SDEV_SAT_SIM_CH4	[unitless]
TREND_AIR_TEMP	[degrees Celsius][meter^-1]

TREND_POTNTL_TEMP	[degrees Kelvin][meter^-1]
TREND_H2O_MIX_RATIO	[grams of water vapor][kilogram dry air^-1] [meter^-1]
TREND_U_COMPNT_WIND_VELOC	[second^-1]
TREND_V_COMPNT_WIND_VELOC	[second^-1]
TREND_STATIC_PRESS	[kiloPascals][meter^-1]
TREND_SURF_RAD_TEMP	[degrees Celsius][meter^-1]
TREND_DOWN_TOTAL_RAD	[Watts][meter^-3]
TREND_UP_TOTAL_RAD	[Watts][meter^-3]
TREND_DOWN_LONGWAVE_RAD	[Watts][meter^-3]
TREND_UP_LONGWAVE_RAD	[Watts][meter^-3]
TREND_GREEN_INDEX	[meter^-1]
TREND_CO2_CONC	[micromoles CO2][mole air^-1][meter^-1]
TREND_O3_CONC	[nanomoles O3][mole air^-1][meter^-1]
TREND_CH4_CONC	[nanomoles CH4][mole air^-1][meter^-1]
SDEV_VERT_GUST_RAW	[meters][second^-1]
SDEV_U_COMPNT_WIND_VELOC_RAW	[meters][second^-1]
SDEV_V_COMPNT_WIND_VELOC_RAW	[meters][second^-1]
SDEV_ALONG_WIND_RAW	[meters][second^-1]
SDEV_CROSS_WIND_RAW	[meters][second^-1]
SDEV_POTNTL_TEMP_RAW	[degrees Kelvin]
SDEV_H2O_MIX_RATIO_RAW	[grams of water vapor][kilogram dry air^-1]
SDEV_CO2_MIX_RATIO_RAW	[unitless]
SDEV_O3_CONC_RAW	[nanomoles O3][mole air^-1]
SDEV_CH4_CONC_RAW	[nanomoles CH4][mole air^-1]
SKEW_VERT_GUST_RAW	[meters][second^-1]
SKEW_U_COMPNT_WIND_VELOC_RAW	[meters][second^-1]
SKEW_V_COMPNT_WIND_VELOC_RAW	[meters][second^-1]
SKEW_ALONG_WIND_RAW	[meters][second^-1]
SKEW_CROSS_WIND_RAW	[meters][second^-1]
SKEW_POTNTL_TEMP_RAW	[degrees Kelvin]
SKEW_H2O_MIX_RATIO_RAW	[grams of water vapor][kilogram dry air^-1]
SKEW_CO2_MIX_RATIO	[unitless]
SKEW_O3_CONC_RAW	[nanomoles O3][mole air^-1]
SKEW_CH4_CONC_RAW	[nanomoles CH4][mole air^-1]
KURT_VERT_GUST_RAW	[meters][second^-1]
KURT_U_COMPNT_WIND_VELOC_RAW	[meters][second^-1]
KURT_V_COMPNT_WIND_VELOC_RAW	[meters][second^-1]
KURT_ALONG_WIND_RAW	[meters][second^-1]
KURT_CROSS_WIND_RAW	[meters][second^-1]
KURT_POTNTL_TEMP_RAW	[degrees Kelvin]
KURT_H2O_MIX_RATIO_RAW	[grams of water vapor][kilogram dry air^-1]
KURT_CO2_MIX_RATIO_RAW	[unitless]
KURT_O3_CONC_RAW	[nanomoles O3][mole air^-1]
KURT_CH4_CONC_RAW	[nanomoles CH4][mole air^-1]
CORC_VERT_U_WIND_COMPNT_RAW	[meters^2][second^-2]
CORC_VERT_V_WIND_COMPNT_RAW	[meters^2][second^-2]
CORC_VERT_ALONG_WIND_RAW	[meters^2][second^-2]
CORC_VERT_CROSS_WIND_RAW	[meters^2][second^-2]
CORC_VERT_POTNTL_TEMP_RAW	[degrees Kelvin][meters][second^-1]
CORC_VERT_H2O_MIX_RATIO_RAW	[grams of water vapor][meters] [kilogram dry air^ -1][second^-1]
CORC_VERT_CO2_MIX_RATIO_RAW	[unitless]
CORC_VERT_O3_CONC_RAW	[nanomoles O3][meters][mole air^-1][second^-1]

CORC_VERT_CH4_CONC_RAW	[nanomoles CH4][meters][mole air^-1][second^-1]
CORC_POTNTL_H2O_MIX_RATIO_RAW	[grams of water vapor][degrees Kelvin] [kilogram dry air^-1]
MMNTM_FLUX_V_WIND_COMPNT_RAW	[Newtons][meter^-2]
MMNTM_FLUX_U_WIND_COMPNT_RAW	[Newtons][meter^-2]
MMNTM_FLUX_ALONG_MEAN_WIND_RAW	[Newtons][meter^-2]
MMNTM_FLUX_CROSS_MEAN_WIND_RAW	[Newtons][meter^-2]
SENSIBLE_HEAT_FLUX_RAW	[Watts][meter^-2]
LATENT_HEAT_FLUX_RAW	[Watts][meter^-2]
CO2_FLUX_RAW	[micromoles CO2][meter^-2][second^-1]
O3_FLUX_RAW	[nanomoles O3][meter^-2][second^-1]
O3_DEPOSITION_VELOC_RAW	[millimeters][second^-1]
CH4_FLUX_RAW	[nanomoles CH4][meter^-2][second^-1]
AIR_DENSITY_CONSTANT	[kilograms][meter^-3]
SPECIFIC_HEAT_CONSTANT	[Joules][kilogram^-1][degree Kelvin^-1]
LATENT_HEAT_VAP_CONSTANT	[Joules][kilogram^-1]
DRY_AIR_GAS_CONSTANT	[Joules][kilogram^-1][degree Kelvin^-1]
SDEV_VERT_GUST_DET	[meters][second^-1]
SDEV_U_COMPNT_WIND_VELOC_DET	[meters][second^-1]
SDEV_V_COMPNT_WIND_VELOC_DET	[meters][second^-1]
SDEV_ALONG_WIND_DET	[meters][second^-1]
SDEV_CROSS_WIND_DET	[meters][second^-1]
SDEV_POTNTL_TEMP_DET	[degrees Kelvin]
SDEV_H2O_MIX_RATIO_DET	[grams of water vapor][kilogram dry air^-1]
SDEV_CO2_MIX_RATIO	[unitless]
SDEV_O3_CONC_DET	[nanomoles O3][mole air^-1]
SDEV_CH4_CONC_DET	[nanomoles CH4][mole air^-1]
SKEW_VERT_GUST_DET	[meters][second^-1]
SKEW_U_COMPNT_WIND_VELOC_DET	[meters][second^-1]
SKEW_V_COMPNT_WIND_VELOC_DET	[meters][second^-1]
SKEW_ALONG_WIND_DET	[meters][second^-1]
SKEW_CROSS_WIND_DET	[meters][second^-1]
SKEW_POTNTL_TEMP_DET	[degrees Kelvin]
SKEW_H2O_MIX_RATIO_DET	[grams of water vapor][kilogram dry air^-1]
SKEW_CO2_MIX_RATIO_DET	[unitless]
SKEW_O3_CONC_DET	[nanomoles O3][mole air^-1]
SKEW_CH4_CONC_DET	[nanomoles CH4][mole air^-1]
KURT_VERT_GUST_DET	[meters][second^-1]
KURT_U_COMPNT_WIND_VELOC_DET	[meters][second^-1]
KURT_V_COMPNT_WIND_VELOC_DET	[meters][second^-1]
KURT_ALONG_WIND_DET	[meters][second^-1]
KURT_CROSS_WIND_DET	[meters][second^-1]
KURT_POTNTL_TEMP_DET	[degrees Kelvin]
KURT_H2O_MIX_RATIO_DET	[grams of water vapor][kilogram dry air^-1]
KURT_CO2_MIX_RATIO_DET	[unitless]
KURT_O3_CONC_DET	[nanomoles O3][mole air^-1]
KURT_CH4_CONC_DET	[nanomoles CH4][mole air^-1]
CORC_VERT_U_WIND_COMPNT_DET	[meters^2][second^-2]
CORC_VERT_V_WIND_COMPNT_DET	[meters^2][second^-2]
CORC_VERT_ALONG_WIND_DET	[meters^2][second^-2]
CORC_VERT_CROSS_WIND_DET	[meters^2][second^-2]
CORC_VERT_POTNTL_TEMP_DET	[degrees Kelvin][meters][second^-1]
CORC_VERT_H2O_MIX_RATIO_DET	[grams of water vapor][meters] [kilogram dry air^ -1][second^-1]

CORC_VERT_CO2_MIX_RATIO_DET	[unitless]
CORC_VERT_O3_CONC_DET	[nanomoles O3][meters][mole air^-1][second^-1]
CORC_VERT_CH4_CONC_DET	[nanomoles CH4][meters][mole air^-1][second^-1]
CORC_POTNTL_H2O_MIX_RATIO_DET	[grams of water vapor][degrees Kelvin] [kilogram dry air^-1]
MMNTM_FLUX_U_WIND_COMPNT_DET	[Newtons][meter^-2]
MMNTM_FLUX_V_WIND_COMPNT_DET	[Newtons][meter^-2]
MMNTM_FLUX_ALONG_MEAN_WIND_DET	[Newtons][meter^-2]
MMNTM_FLUX_CROSS_MEAN_WIND_DET	[Newtons][meter^-2]
SENSIBLE_HEAT_FLUX_DET	[Watts][meter^-2]
LATENT_HEAT_FLUX_DET	[Watts][meter^-2]
CO2_FLUX_DET	[micromoles CO2][meter^-2][second^-1]
O3_FLUX_DET	[nanomoles O3][meter^-2][second^-1]
O3_DEPOSITION_VELOC_DET	[millimeters][second^-1]
CH4_FLUX_DET	[nanomoles CH4][meter^-2][second^-1]
CRTFCN_CODE	[none]
REVISION_DATE	[DD-MON-YY]

7.3.4 Data Source

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

Column Name	Data Source
SPATIAL_COVERAGE	[Assigned by BORIS.]
RUN_START_DATE	[Supplied by AFM-04.]
RUN_START_TIME	[Supplied by AFM-04.]
RUN_END_DATE	[Supplied by AFM-04.]
RUN_END_TIME	[Supplied by AFM-04.]
FLUX_MISSION_DESIGNATOR	[Supplied by AFM-04.]
FLUX_MISSION_NUM	[Supplied by AFM-04.]
FLUX_PASS_NUM	[Supplied by AFM-04.]
FLUX_SEGMENT_NUM	[Supplied by AFM-04.]
START_LATITUDE	[Supplied by AFM-04.]
START_LONGITUDE	[Supplied by AFM-04.]
END_LATITUDE	[Supplied by AFM-04.]
END_LONGITUDE	[Supplied by AFM-04.]
START_BOREAS_X	[Supplied by AFM-04.]
START_BOREAS_Y	[Supplied by AFM-04.]
END_BOREAS_X	[Supplied by AFM-04.]
END_BOREAS_Y	[Supplied by AFM-04.]
HEADING	[Supplied by AFM-04.]
MEAN_PRESS_ALTITUDE	[Supplied by AFM-04.]
MEAN_RADAR_ALTITUDE	[Supplied by AFM-04.]
MEAN_WIND_DIR	[Supplied by AFM-04.]
MEAN_WIND_SPEED	[Supplied by AFM-04.]
MEAN_AIR_TEMP	[Supplied by AFM-04.]
MEAN_POTNTL_TEMP	[Supplied by AFM-04.]
MEAN_H2O_MIX_RATIO	[Supplied by AFM-04.]
MEAN_U_COMPNT_WIND_VELOC	[Supplied by AFM-04.]
MEAN_V_COMPNT_WIND_VELOC	[Supplied by AFM-04.]
MEAN_STATIC_PRESS	[Supplied by AFM-04.]
MEAN_SURF_RAD_TEMP	[Supplied by AFM-04.]
MEAN_DOWN_TOTAL_RAD	[Supplied by AFM-04.]
MEAN_UP_TOTAL_RAD	[Supplied by AFM-04.]

MEAN_DOWN_LONGWAVE_RAD	[Supplied by AFM-04.]
MEAN_UP_LONGWAVE_RAD	[Supplied by AFM-04.]
MEAN_NET_RAD	[Supplied by AFM-04.]
MEAN_UP_PPFD	[Supplied by AFM-04.]
MEAN_DOWN_PPFD	[Supplied by AFM-04.]
MEAN_AUX_RAD	[Supplied by AFM-04.]
MEAN_GREEN_INDEX	[Supplied by AFM-04.]
MEAN_CO2_CONC	[Supplied by AFM-04.]
MEAN_O3_CONC	[Supplied by AFM-04.]
MEAN_CH4_CONC	[Supplied by AFM-04.]
MEAN_SAT_SIM_CH1	[Supplied by AFM-04.]
MEAN_SAT_SIM_CH2	[Supplied by AFM-04.]
MEAN_SAT_SIM_CH3	[Supplied by AFM-04.]
MEAN_SAT_SIM_CH4	[Supplied by AFM-04.]
SDEV_AIR_TEMP	[Supplied by AFM-04.]
SDEV_POTNTL_TEMP	[Supplied by AFM-04.]
SDEV_H2O_MIX_RATIO	[Supplied by AFM-04.]
SDEV_U_COMPNT_WIND_VELOC	[Supplied by AFM-04.]
SDEV_V_COMPNT_WIND_VELOC	[Supplied by AFM-04.]
SDEV_STATIC_PRESS	[Supplied by AFM-04.]
SDEV_SURF_RAD_TEMP	[Supplied by AFM-04.]
SDEV_DOWN_TOTAL_RAD	[Supplied by AFM-04.]
SDEV_UP_TOTAL_RAD	[Supplied by AFM-04.]
SDEV_DOWN_LONGWAVE_RAD	[Supplied by AFM-04.]
SDEV_UP_LONGWAVE_RAD	[Supplied by AFM-04.]
SDEV_NET_RAD	[Supplied by AFM-04.]
SDEV_UP_PPFD	[Supplied by AFM-04.]
SDEV_DOWN_PPFD	[Supplied by AFM-04.]
SDEV_AUX_RAD	[Supplied by AFM-04.]
SDEV_GREEN_INDEX	[Supplied by AFM-04.]
SDEV_CO2_CONC	[Supplied by AFM-04.]
SDEV_O3_CONC	[Supplied by AFM-04.]
SDEV_CH4_CONC	[Supplied by AFM-04.]
SDEV_SAT_SIM_CH1	[Supplied by AFM-04.]
SDEV_SAT_SIM_CH2	[Supplied by AFM-04.]
SDEV_SAT_SIM_CH3	[Supplied by AFM-04.]
SDEV_SAT_SIM_CH4	[Supplied by AFM-04.]
TREND_AIR_TEMP	[Supplied by AFM-04.]
TREND_POTNTL_TEMP	[Supplied by AFM-04.]
TREND_H2O_MIX_RATIO	[Supplied by AFM-04.]
TREND_U_COMPNT_WIND_VELOC	[Supplied by AFM-04.]
TREND_V_COMPNT_WIND_VELOC	[Supplied by AFM-04.]
TREND_STATIC_PRESS	[Supplied by AFM-04.]
TREND_SURF_RAD_TEMP	[Supplied by AFM-04.]
TREND_DOWN_TOTAL_RAD	[Supplied by AFM-04.]
TREND_UP_TOTAL_RAD	[Supplied by AFM-04.]
TREND_DOWN_LONGWAVE_RAD	[Supplied by AFM-04.]
TREND_UP_LONGWAVE_RAD	[Supplied by AFM-04.]
TREND_GREEN_INDEX	[Supplied by AFM-04.]
TREND_CO2_CONC	[Supplied by AFM-04.]
TREND_O3_CONC	[Supplied by AFM-04.]
TREND_CH4_CONC	[Supplied by AFM-04.]
SDEV_VERT_GUST_RAW	[Supplied by AFM-04.]
SDEV_U_COMPNT_WIND_VELOC_RAW	[Supplied by AFM-04.]

SDEV_V_COMPNT_WIND_VELOC_RAW	[Supplied by AFM-04.]
SDEV_ALONG_WIND_RAW	[Supplied by AFM-04.]
SDEV_CROSS_WIND_RAW	[Supplied by AFM-04.]
SDEV_POTNTL_TEMP_RAW	[Supplied by AFM-04.]
SDEV_H2O_MIX_RATIO_RAW	[Supplied by AFM-04.]
SDEV_CO2_MIX_RATIO_RAW	[Supplied by AFM-04.]
SDEV_O3_CONC_RAW	[Supplied by AFM-04.]
SDEV_CH4_CONC_RAW	[Supplied by AFM-04.]
SKEW_VERT_GUST_RAW	[Supplied by AFM-04.]
SKEW_U_COMPNT_WIND_VELOC_RAW	[Supplied by AFM-04.]
SKEW_V_COMPNT_WIND_VELOC_RAW	[Supplied by AFM-04.]
SKEW_ALONG_WIND_RAW	[Supplied by AFM-04.]
SKEW_CROSS_WIND_RAW	[Supplied by AFM-04.]
SKEW_POTNTL_TEMP_RAW	[Supplied by AFM-04.]
SKEW_H2O_MIX_RATIO_RAW	[Supplied by AFM-04.]
SKEW_CO2_MIX_RATIO	[Supplied by AFM-04.]
SKEW_O3_CONC_RAW	[Supplied by AFM-04.]
SKEW_CH4_CONC_RAW	[Supplied by AFM-04.]
KURT_VERT_GUST_RAW	[Supplied by AFM-04.]
KURT_U_COMPNT_WIND_VELOC_RAW	[Supplied by AFM-04.]
KURT_V_COMPNT_WIND_VELOC_RAW	[Supplied by AFM-04.]
KURT_ALONG_WIND_RAW	[Supplied by AFM-04.]
KURT_CROSS_WIND_RAW	[Supplied by AFM-04.]
KURT_POTNTL_TEMP_RAW	[Supplied by AFM-04.]
KURT_H2O_MIX_RATIO_RAW	[Supplied by AFM-04.]
KURT_CO2_MIX_RATIO_RAW	[Supplied by AFM-04.]
KURT_O3_CONC_RAW	[Supplied by AFM-04.]
KURT_CH4_CONC_RAW	[Supplied by AFM-04.]
CORC_VERT_U_WIND_COMPNT_RAW	[Supplied by AFM-04.]
CORC_VERT_V_WIND_COMPNT_RAW	[Supplied by AFM-04.]
CORC_VERT_ALONG_WIND_RAW	[Supplied by AFM-04.]
CORC_VERT_CROSS_WIND_RAW	[Supplied by AFM-04.]
CORC_VERT_POTNTL_TEMP_RAW	[Supplied by AFM-04.]
CORC_VERT_H2O_MIX_RATIO_RAW	[Supplied by AFM-04.]
CORC_VERT_CO2_MIX_RATIO_RAW	[Supplied by AFM-04.]
CORC_VERT_O3_CONC_RAW	[Supplied by AFM-04.]
CORC_VERT_CH4_CONC_RAW	[Supplied by AFM-04.]
CORC_POTNTL_H2O_MIX_RATIO_RAW	[Supplied by AFM-04.]
MMNTM_FLUX_V_WIND_COMPNT_RAW	[Supplied by AFM-04.]
MMNTM_FLUX_U_WIND_COMPNT_RAW	[Supplied by AFM-04.]
MMNTM_FLUX_ALONG_MEAN_WIND_RAW	[Supplied by AFM-04.]
MMNTM_FLUX_CROSS_MEAN_WIND_RAW	[Supplied by AFM-04.]
SENSIBLE_HEAT_FLUX_RAW	[Supplied by AFM-04.]
LATENT_HEAT_FLUX_RAW	[Supplied by AFM-04.]
CO2_FLUX_RAW	[Supplied by AFM-04.]
O3_FLUX_RAW	[Supplied by AFM-04.]
O3_DEPOSITION_VELOC_RAW	[Supplied by AFM-04.]
CH4_FLUX_RAW	[Supplied by AFM-04.]
AIR_DENSITY_CONSTANT	[Supplied by AFM-04.]
SPECIFIC_HEAT_CONSTANT	[Supplied by AFM-04.]
LATENT_HEAT_VAP_CONSTANT	[Supplied by AFM-04.]
DRY_AIR_GAS_CONSTANT	[Supplied by AFM-04.]
SDEV_VERT_GUST_DET	[Supplied by AFM-04.]
SDEV_U_COMPNT_WIND_VELOC_DET	[Supplied by AFM-04.]

SDEV_V_COMPNT_WIND_VELOC_DET	[Supplied by AFM-04.]
SDEV_ALONG_WIND_DET	[Supplied by AFM-04.]
SDEV_CROSS_WIND_DET	[Supplied by AFM-04.]
SDEV_POTNTL_TEMP_DET	[Supplied by AFM-04.]
SDEV_H2O_MIX_RATIO_DET	[Supplied by AFM-04.]
SDEV_CO2_MIX_RATIO	[Supplied by AFM-04.]
SDEV_O3_CONC_DET	[Supplied by AFM-04.]
SDEV_CH4_CONC_DET	[Supplied by AFM-04.]
SKEW_VERT_GUST_DET	[Supplied by AFM-04.]
SKEW_U_COMPNT_WIND_VELOC_DET	[Supplied by AFM-04.]
SKEW_V_COMPNT_WIND_VELOC_DET	[Supplied by AFM-04.]
SKEW_ALONG_WIND_DET	[Supplied by AFM-04.]
SKEW_CROSS_WIND_DET	[Supplied by AFM-04.]
SKEW_POTNTL_TEMP_DET	[Supplied by AFM-04.]
SKEW_H2O_MIX_RATIO_DET	[Supplied by AFM-04.]
SKEW_CO2_MIX_RATIO_DET	[Supplied by AFM-04.]
SKEW_O3_CONC_DET	[Supplied by AFM-04.]
SKEW_CH4_CONC_DET	[Supplied by AFM-04.]
KURT_VERT_GUST_DET	[Supplied by AFM-04.]
KURT_U_COMPNT_WIND_VELOC_DET	[Supplied by AFM-04.]
KURT_V_COMPNT_WIND_VELOC_DET	[Supplied by AFM-04.]
KURT_ALONG_WIND_DET	[Supplied by AFM-04.]
KURT_CROSS_WIND_DET	[Supplied by AFM-04.]
KURT_POTNTL_TEMP_DET	[Supplied by AFM-04.]
KURT_H2O_MIX_RATIO_DET	[Supplied by AFM-04.]
KURT_CO2_MIX_RATIO_DET	[Supplied by AFM-04.]
KURT_O3_CONC_DET	[Supplied by AFM-04.]
KURT_CH4_CONC_DET	[Supplied by AFM-04.]
CORC_VERT_U_WIND_COMPNT_DET	[Supplied by AFM-04.]
CORC_VERT_V_WIND_COMPNT_DET	[Supplied by AFM-04.]
CORC_VERT_ALONG_WIND_DET	[Supplied by AFM-04.]
CORC_VERT_CROSS_WIND_DET	[Supplied by AFM-04.]
CORC_VERT_POTNTL_TEMP_DET	[Supplied by AFM-04.]
CORC_VERT_H2O_MIX_RATIO_DET	[Supplied by AFM-04.]
CORC_VERT_CO2_MIX_RATIO_DET	[Supplied by AFM-04.]
CORC_VERT_O3_CONC_DET	[Supplied by AFM-04.]
CORC_VERT_CH4_CONC_DET	[Supplied by AFM-04.]
CORC_POTNTL_H2O_MIX_RATIO_DET	[Supplied by AFM-04.]
MMNTM_FLUX_U_WIND_COMPNT_DET	[Supplied by AFM-04.]
MMNTM_FLUX_V_WIND_COMPNT_DET	[Supplied by AFM-04.]
MMNTM_FLUX_ALONG_MEAN_WIND_DET	[Supplied by AFM-04.]
MMNTM_FLUX_CROSS_MEAN_WIND_DET	[Supplied by AFM-04.]
SENSIBLE_HEAT_FLUX_DET	[Supplied by AFM-04.]
LATENT_HEAT_FLUX_DET	[Supplied by AFM-04.]
CO2_FLUX_DET	[Supplied by AFM-04.]
O3_FLUX_DET	[Supplied by AFM-04.]
O3_DEPOSITION_VELOC_DET	[Supplied by AFM-04.]
CH4_FLUX_DET	[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
RUN_START_DATE	25-MAY-94	08-AUG-96	None	None	None	None
RUN_START_TIME	144728	225641	None	None	None	None
RUN_END_DATE	25-MAY-94	08-AUG-96	None	None	None	None
RUN_END_TIME	145137	230220	None	None	None	None
FLUX_MISSION_DESIGNATOR	AG	TS	None	None	None	None
FLUX_MISSION_NUM	1	8	None	None	None	None
FLUX_PASS_NUM	1	18	None	None	None	None
FLUX_SEGMENT_NUM	0	9	None	None	None	None
START_LATITUDE	53.332	55.94959	-999	None	None	None
START_LONGITUDE	-106.398	-97.99917	-999	None	None	None
END_LATITUDE	53.33467	55.96583	-999	None	None	None
END_LONGITUDE	-106.4038	-97.99467	-999	None	None	None
START_BOREAS_X	304.372	807.724	-999	None	None	None
START_BOREAS_Y	273.935	621.895	-999	None	None	None
END_BOREAS_X	86.463	808.028	-999	None	None	None
END_BOREAS_Y	274.246	9524.933	-999	None	None	None
HEADING	.1	359.8	None	None	None	None
MEAN_PRESS_ALTITUDE	261.5	2621.8	None	None	None	None
MEAN_RADAR_ALTITUDE	0	800.4	-999	None	None	None
MEAN_WIND_DIR	0	359.9	None	None	None	None
MEAN_WIND_SPEED	.06	11.32	None	None	None	None
MEAN_AIR_TEMP	-.67	28.4	None	None	None	None
MEAN_POTNTL_TEMP	283.13	307.47	None	None	None	None
MEAN_H2O_MIX_RATIO	.68	12.33	None	None	None	None
MEAN_U_COMPNT_WIND_VELOC	-7.74	9.55	None	None	None	None
MEAN_V_COMPNT_WIND_VELOC	-7.8	9.49	None	None	None	None
MEAN_STATIC_PRESS	72.73	99.16	None	None	None	None
MEAN_SURF_RAD_TEMP	7.9	36.7	None	None	None	None
MEAN_DOWN_TOTAL_RAD	151.7	1301.3	None	None	None	None
MEAN_UP_TOTAL_RAD	14.1	173.3	None	None	None	None
MEAN_DOWN_LONGWAVE_RAD			-999	None	None	None
MEAN_UP_LONGWAVE_RAD			-999	None	None	None
MEAN_NET_RAD	59.9	871.5	-999	None	None	None
MEAN_UP_PPFD			-999	None	None	None
MEAN_DOWN_PPFD			-999	None	None	None
MEAN_AUX_RAD			-999	None	None	None
MEAN_GREEN_INDEX	.54	4.89	None	None	None	None
MEAN_CO2_CONC	338.3	385.9	None	None	None	None
MEAN_O3_CONC	-6.09	63.54	None	None	None	None
MEAN_CH4_CONC			-999	None	None	None
MEAN_SAT_SIM_CH1	0	10.89	None	None	None	None

MEAN_SAT_SIM_CH2	-.01	13.03	None	None	None	None
MEAN_SAT_SIM_CH3	-.03	26.65	None	None	None	None
MEAN_SAT_SIM_CH4	0	52.72	None	None	None	None
SDEV_AIR_TEMP	.04	1.22	None	None	None	None
SDEV_POTNTL_TEMP	.04	1.3	None	None	None	None
SDEV_H2O_MIX_RATIO	.02	1.07	None	None	None	None
SDEV_U_COMPNT_WIND_ VELOC	.1	4.41	None	None	None	None
SDEV_V_COMPNT_WIND_ VELOC	.1	3.58	None	None	None	None
SDEV_STATIC_PRESS	.01	.51	None	None	None	None
SDEV_SURF_RAD_TEMP	.21	8.23	None	None	None	None
SDEV_DOWN_TOTAL_RAD	2.1	798.9	-999	None	None	None
SDEV_UP_TOTAL_RAD	.2	57.1	None	None	None	None
SDEV_DOWN_LONGWAVE_ RAD			-999	None	None	None
SDEV_UP_LONGWAVE_RAD			-999	None	None	None
SDEV_NET_RAD	3.4	793.4	-999	None	None	None
SDEV_UP_PPFD			-999	None	None	None
SDEV_DOWN_PPFD			-999	None	None	None
SDEV_AUX_RAD			-999	None	None	None
SDEV_GREEN_INDEX	.01	1.22	None	None	None	None
SDEV_CO2_CONC	.2	6.2	None	None	None	None
SDEV_O3_CONC	.05	26.22	None	None	None	None
SDEV_CH4_CONC			-999	None	None	None
SDEV_SAT_SIM_CH1	0	10.74	None	None	None	None
SDEV_SAT_SIM_CH2	0	10.94	None	None	None	None
SDEV_SAT_SIM_CH3	0	10.64	None	None	None	None
SDEV_SAT_SIM_CH4	0	21.67	None	None	None	None
TREND_AIR_TEMP	-.000572	.000797	None	None	None	None
TREND_POTNTL_TEMP	-.000569	.000835	None	None	None	None
TREND_H2O_MIX_RATIO	-.000634	.000417	None	None	None	None
TREND_U_COMPNT_WIND_ VELOC	-.00229	.00388	None	None	None	None
TREND_V_COMPNT_WIND_ VELOC	-.00237	.00191	None	None	None	None
TREND_STATIC_PRESS	-.000253	.000702	None	None	None	None
TREND_SURF_RAD_TEMP	-.00582	.00692	None	None	None	None
TREND_DOWN_TOTAL_RAD	-.332	.333	None	None	None	None
TREND_UP_TOTAL_RAD	-.0389	.0383	None	None	None	None
TREND_DOWN_LONGWAVE_ RAD			-999	None	None	None
TREND_UP_LONGWAVE_ RAD			-999	None	None	None
TREND_GREEN_INDEX	-.000699	.000576	None	None	None	None
TREND_CO2_CONC	-.00103	.00109	None	None	None	None
TREND_O3_CONC	-.0121	.0204	None	None	None	None
TREND_CH4_CONC			-999	None	None	None
SDEV_VERT_GUST_RAW	.04	2.4	None	None	None	None
SDEV_U_COMPNT_WIND_ VELOC_RAW	.1	4.41	None	None	None	None
SDEV_V_COMPNT_WIND_ VELOC_RAW	.1	3.58	None	None	None	None
SDEV_ALONG_WIND_RAW	.08	3.82	None	None	None	None

SDEV_CROSS_WIND_RAW	.13	2.9	None	None	None	None
SDEV_POTNTL_TEMP_RAW	.04	1.3	None	None	None	None
SDEV_H2O_MIX_RATIO_ RAW	.02	1.07	None	None	None	None
SDEV_CO2_MIX_RATIO_ RAW	.2	6.2	None	None	None	None
SDEV_O3_CONC_RAW	0	9.32	None	None	None	None
SDEV_CH4_CONC_RAW			-999	None	None	None
SKEW_VERT_GUST_RAW			-999	None	None	None
SKEW_U_COMPNT_WIND_ VELOC_RAW			-999	None	None	None
SKEW_V_COMPNT_WIND_ VELOC_RAW			-999	None	None	None
SKEW_ALONG_WIND_RAW			-999	None	None	None
SKEW_CROSS_WIND_RAW			-999	None	None	None
SKEW_POTNTL_TEMP_RAW			-999	None	None	None
SKEW_H2O_MIX_RATIO_ RAW			-999	None	None	None
SKEW_CO2_MIX_RATIO			-999	None	None	None
SKEW_O3_CONC_RAW			-999	None	None	None
SKEW_CH4_CONC_RAW			-999	None	None	None
KURT_VERT_GUST_RAW			-999	None	None	None
KURT_U_COMPNT_WIND_ VELOC_RAW			-999	None	None	None
KURT_V_COMPNT_WIND_ VELOC_RAW			-999	None	None	None
KURT_ALONG_WIND_RAW			-999	None	None	None
KURT_CROSS_WIND_RAW			-999	None	None	None
KURT_POTNTL_TEMP_RAW			-999	None	None	None
KURT_H2O_MIX_RATIO_ RAW			-999	None	None	None
KURT_CO2_MIX_RATIO_ RAW			-999	None	None	None
KURT_O3_CONC_RAW			-999	None	None	None
KURT_CH4_CONC_RAW			-999	None	None	None
CORC_VERT_U_WIND_ COMPNT_RAW	-.6	.87	None	None	None	None
CORC_VERT_V_WIND_ COMPNT_RAW	-.73	.62	None	None	None	None
CORC_VERT_ALONG_WIND_ RAW	-.86	.6	None	None	None	None
CORC_VERT_CROSS_WIND_ RAW	-.84	.59	None	None	None	None
CORC_VERT_POTNTL_ TEMP_RAW	-.75	.8	None	None	None	None
CORC_VERT_H2O_MIX_ RATIO_RAW	-.68	.76	None	None	None	None
CORC_VERT_CO2_MIX_ RATIO_RAW	-.63	.58	None	None	None	None
CORC_VERT_O3_CONC_ RAW	-.61	1.88	None	None	None	None
CORC_VERT_CH4_CONC_ RAW			-999	None	None	None
CORC_POTNTL_H2O_MIX_	-7.57	11.16	-999	None	None	None

RATIO_RAW						
MMNTM_FLUX_V_WIND_ COMPNT_RAW	-1.3857	10	None	None	None	None
MMNTM_FLUX_U_WIND_ COMPNT_RAW	-3.5566	1.4309	None	None	None	None
MMNTM_FLUX_ALONG_ MEAN_WIND_RAW	-3.1398	.447	None	None	None	None
MMNTM_FLUX_CROSS_ MEAN_WIND_RAW	-2.6673	1.203	None	None	None	None
SENSIBLE_HEAT_FLUX_ RAW	-122.4	489.5	None	None	None	None
LATENT_HEAT_FLUX_RAW	-353.6	755	None	None	None	None
CO2_FLUX_RAW	-26.21	10.188	None	None	None	None
O3_FLUX_RAW	-35.735	46.179	-999	None	None	None
O3_DEPOSITION_VELOC_ RAW	-28.3	45.5	-999	None	None	None
CH4_FLUX_RAW			-999	None	None	None
AIR_DENSITY_CONSTANT	.903	11	None	None	None	None
SPECIFIC_HEAT_ CONSTANT	240	240	None	None	None	None
LATENT_HEAT_VAP_ CONSTANT	2434	2503	None	None	None	None
DRY_AIR_GAS_CONSTANT	2.87	2.87	None	None	None	None
SDEV_VERT_GUST_DET	.03	12	None	None	None	None
SDEV_U_COMPNT_WIND_ VELOC_DET	.05	3.8	None	None	None	None
SDEV_V_COMPNT_WIND_ VELOC_DET	.08	3.16	None	None	None	None
SDEV_ALONG_WIND_DET	.06	3.75	None	None	None	None
SDEV_CROSS_WIND_DET	.1	2.57	None	None	None	None
SDEV_POTNTL_TEMP_DET	.03	1.26	None	None	None	None
SDEV_H2O_MIX_RATIO_ DET	.02	.95	None	None	None	None
SDEV_CO2_MIX_RATIO	.2	5.6	None	None	None	None
SDEV_O3_CONC_DET	0	9.32	None	None	None	None
SDEV_CH4_CONC_DET			-999	None	None	None
SKEW_VERT_GUST_DET	-1.69	13	None	None	None	None
SKEW_U_COMPNT_WIND_ VELOC_DET	-1.74	3.57	None	None	None	None
SKEW_V_COMPNT_WIND_ VELOC_DET	-11.34	2.03	None	None	None	None
SKEW_ALONG_WIND_DET			-999	None	None	None
SKEW_CROSS_WIND_DET			-999	None	None	None
SKEW_POTNTL_TEMP_DET	-2.3	4.17	None	None	None	None
SKEW_H2O_MIX_RATIO_ DET	-1.92	2.38	None	None	None	None
SKEW_CO2_MIX_RATIO_ DET	-5.54	15.7	None	None	None	None
SKEW_O3_CONC_DET	-4.56	2.06	None	None	None	None
SKEW_CH4_CONC_DET			-999	None	None	None
KURT_VERT_GUST_DET	1.99	55.59	None	None	None	None
KURT_U_COMPNT_WIND_ VELOC_DET	1.73	54.94	None	None	None	None
KURT_V_COMPNT_WIND_	1.89	18.02	-999	None	None	None

VELOC_DET						
KURT_ALONG_WIND_DET			-999	None	None	None
KURT_CROSS_WIND_DET			-999	None	None	None
KURT_POTNTL_TEMP_DET	1.83	31.52	None	None	None	None
KURT_H2O_MIX_RATIO_ DET	1.44	14.48	None	None	None	None
KURT_CO2_MIX_RATIO_ DET	1.74	95.04	None	None	None	None
KURT_O3_CONC_DET	0	34.58	None	None	None	None
KURT_CH4_CONC_DET			-999	None	None	None
CORC_VERT_U_WIND_ COMPNT_DET	-.64	15	None	None	None	None
CORC_VERT_V_WIND_ COMPNT_DET	-.73	.63	None	None	None	None
CORC_VERT_ALONG_WIND_ DET	-.71	.52	None	None	None	None
CORC_VERT_CROSS_WIND_ DET	-.74	.58	None	None	None	None
CORC_VERT_POTNTL_ TEMP_DET	-.67	.8	None	None	None	None
CORC_VERT_H2O_MIX_ RATIO_DET	-.68	.74	None	None	None	None
CORC_VERT_CO2_MIX_ RATIO_DET	-.67	.43	None	None	None	None
CORC_VERT_O3_CONC_ DET	-.59	1.88	None	None	None	None
CORC_VERT_CH4_CONC_ DET			-999	None	None	None
CORC_POTNTL_H2O_MIX_ RATIO_DET	-.93	.9	None	None	None	None
MMNTM_FLUX_U_WIND_ COMPNT_DET	-1.5758	16	None	None	None	None
MMNTM_FLUX_V_WIND_ COMPNT_DET	-3.4116	1.3096	None	None	None	None
MMNTM_FLUX_ALONG_ MEAN_WIND_DET	-2.9921	.3646	None	None	None	None
MMNTM_FLUX_CROSS_ MEAN_WIND_DET	-2.6699	1.211	None	None	None	None
SENSIBLE_HEAT_FLUX_ DET	-54.9	490.2	None	None	None	None
LATENT_HEAT_FLUX_DET	-269.6	557.5	None	None	None	None
CO2_FLUX_DET	-26.219	10.796	None	None	None	None
O3_FLUX_DET	-22.952	44.792	-999	None	None	None
O3_DEPOSITION_VELOC_ DET	-27.5	32.3	-999	None	None	None
CH4_FLUX_DET			-999	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	12-AUG-96	25-JUN-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,RUN_START_DATE,RUN_START_TIME,RUN_END_DATE,RUN_END_TIME,
FLUX_MISSION_DESIGNATOR,FLUX_MISSION_NUM,FLUX_PASS_NUM,FLUX_SEGMENT_NUM,
START_LATITUDE,START_LONGITUDE,END_LATITUDE,END_LONGITUDE,START_BOREAS_X,
START_BOREAS_Y,END_BOREAS_X,END_BOREAS_Y,HEADING,MEAN_PRESS_ALTITUDE,
MEAN_RADAR_ALTITUDE,MEAN_WIND_DIR,MEAN_WIND_SPEED,MEAN_AIR_TEMP,
MEAN_POTNTL_TEMP,MEAN_H2O_MIX_RATIO,MEAN_U_COMPNT_WIND_VELOC,
MEAN_V_COMPNT_WIND_VELOC,MEAN_STATIC_PRESS,MEAN_SURF_RAD_TEMP,
MEAN_DOWN_TOTAL_RAD,MEAN_UP_TOTAL_RAD,MEAN_DOWN_LONGWAVE_RAD,
MEAN_UP_LONGWAVE_RAD,MEAN_NET_RAD,MEAN_UP_PPFD,MEAN_DOWN_PPFD,MEAN_AUX_RAD,
MEAN_GREEN_INDEX,MEAN_CO2_CONC,MEAN_O3_CONC,MEAN_CH4_CONC,MEAN_SAT_SIM_CH1,
MEAN_SAT_SIM_CH2,MEAN_SAT_SIM_CH3,MEAN_SAT_SIM_CH4,SDEV_AIR_TEMP,
SDEV_POTNTL_TEMP,SDEV_H2O_MIX_RATIO,SDEV_U_COMPNT_WIND_VELOC,
SDEV_V_COMPNT_WIND_VELOC,SDEV_STATIC_PRESS,SDEV_SURF_RAD_TEMP,
SDEV_DOWN_TOTAL_RAD,SDEV_UP_TOTAL_RAD,SDEV_DOWN_LONGWAVE_RAD,
SDEV_UP_LONGWAVE_RAD,SDEV_NET_RAD,SDEV_UP_PPFD,SDEV_DOWN_PPFD,SDEV_AUX_RAD,
SDEV_GREEN_INDEX,SDEV_CO2_CONC,SDEV_O3_CONC,SDEV_CH4_CONC,SDEV_SAT_SIM_CH1,
SDEV_SAT_SIM_CH2,SDEV_SAT_SIM_CH3,SDEV_SAT_SIM_CH4,TREND_AIR_TEMP,
TREND_POTNTL_TEMP,TREND_H2O_MIX_RATIO,TREND_U_COMPNT_WIND_VELOC,
TREND_V_COMPNT_WIND_VELOC,TREND_STATIC_PRESS,TREND_SURF_RAD_TEMP,
TREND_DOWN_TOTAL_RAD,TREND_UP_TOTAL_RAD,TREND_DOWN_LONGWAVE_RAD,
TREND_UP_LONGWAVE_RAD,TREND_GREEN_INDEX,TREND_CO2_CONC,TREND_O3_CONC,
TREND_CH4_CONC,SDEV_VERT_GUST_RAW,SDEV_U_COMPNT_WIND_VELOC_RAW,
SDEV_V_COMPNT_WIND_VELOC_RAW,SDEV_ALONG_WIND_RAW,SDEV_CROSS_WIND_RAW,
SDEV_POTNTL_TEMP_RAW,SDEV_H2O_MIX_RATIO_RAW,SDEV_CO2_MIX_RATIO_RAW,
SDEV_O3_CONC_RAW,SDEV_CH4_CONC_RAW,SKEW_VERT_GUST_RAW,
SKEW_U_COMPNT_WIND_VELOC_RAW,SKEW_V_COMPNT_WIND_VELOC_RAW,SKEW_ALONG_WIND_RAW,
SKEW_CROSS_WIND_RAW,SKEW_POTNTL_TEMP_RAW,SKEW_H2O_MIX_RATIO_RAW,
SKEW_CO2_MIX_RATIO,SKEW_O3_CONC_RAW,SKEW_CH4_CONC_RAW,KURT_VERT_GUST_RAW,
```

KURT_U_COMPNT_WIND_VELOC_RAW,KURT_V_COMPNT_WIND_VELOC_RAW,KURT_ALONG_WIND_RAW,
KURT_CROSS_WIND_RAW,KURT_POTNTL_TEMP_RAW,KURT_H2O_MIX_RATIO_RAW,
KURT_CO2_MIX_RATIO_RAW,KURT_O3_CONC_RAW,KURT_CH4_CONC_RAW,
CORC_VERT_U_WIND_COMPNT_RAW,CORC_VERT_V_WIND_COMPNT_RAW,
CORC_VERT_ALONG_WIND_RAW,CORC_VERT_CROSS_WIND_RAW,CORC_VERT_POTNTL_TEMP_RAW,
CORC_VERT_H2O_MIX_RATIO_RAW,CORC_VERT_CO2_MIX_RATIO_RAW,CORC_VERT_O3_CONC_RAW,
CORC_VERT_CH4_CONC_RAW,CORC_POTNTL_H2O_MIX_RATIO_RAW,
MMNTM_FLUX_V_WIND_COMPNT_RAW,MMNTM_FLUX_U_WIND_COMPNT_RAW,
MMNTM_FLUX_ALONG_MEAN_WIND_RAW,MMNTM_FLUX_CROSS_MEAN_WIND_RAW,
SENSIBLE_HEAT_FLUX_RAW,LATENT_HEAT_FLUX_RAW,CO2_FLUX_RAW,O3_FLUX_RAW,
O3_DEPOSITION_VELOC_RAW,CH4_FLUX_RAW,AIR_DENSITY_CONSTANT,
SPECIFIC_HEAT_CONSTANT,LATENT_HEAT_VAP_CONSTANT,DRY_AIR_GAS_CONSTANT,
SDEV_VERT_GUST_DET,SDEV_U_COMPNT_WIND_VELOC_DET,SDEV_V_COMPNT_WIND_VELOC_DET,
SDEV_ALONG_WIND_DET,SDEV_CROSS_WIND_DET,SDEV_POTNTL_TEMP_DET,
SDEV_H2O_MIX_RATIO_DET,SDEV_CO2_MIX_RATIO,SDEV_O3_CONC_DET,SDEV_CH4_CONC_DET,
SKEW_VERT_GUST_DET,SKEW_U_COMPNT_WIND_VELOC_DET,SKEW_V_COMPNT_WIND_VELOC_DET,
SKEW_ALONG_WIND_DET,SKEW_CROSS_WIND_DET,SKEW_POTNTL_TEMP_DET,
SKEW_H2O_MIX_RATIO_DET,SKEW_CO2_MIX_RATIO_DET,SKEW_O3_CONC_DET,
SKEW_CH4_CONC_DET,KURT_VERT_GUST_DET,KURT_U_COMPNT_WIND_VELOC_DET,
KURT_V_COMPNT_WIND_VELOC_DET,KURT_ALONG_WIND_DET,KURT_CROSS_WIND_DET,
KURT_POTNTL_TEMP_DET,KURT_H2O_MIX_RATIO_DET,KURT_CO2_MIX_RATIO_DET,
KURT_O3_CONC_DET,KURT_CH4_CONC_DET,CORC_VERT_U_WIND_COMPNT_DET,
CORC_VERT_V_WIND_COMPNT_DET,CORC_VERT_ALONG_WIND_DET,CORC_VERT_CROSS_WIND_DET,
CORC_VERT_POTNTL_TEMP_DET,CORC_VERT_H2O_MIX_RATIO_DET,
CORC_VERT_CO2_MIX_RATIO_DET,CORC_VERT_O3_CONC_DET,CORC_VERT_CH4_CONC_DET,
CORC_POTNTL_H2O_MIX_RATIO_DET,MMNTM_FLUX_U_WIND_COMPNT_DET,
MMNTM_FLUX_V_WIND_COMPNT_DET,MMNTM_FLUX_ALONG_MEAN_WIND_DET,
MMNTM_FLUX_CROSS_MEAN_WIND_DET,SENSIBLE_HEAT_FLUX_DET,LATENT_HEAT_FLUX_DET,
CO2_FLUX_DET,O3_FLUX_DET,O3_DEPOSITION_VELOC_DET,CH4_FLUX_DET,CRTFCN_CODE,
REVISION_DATE
'SSA',26-MAY-94,161101,26-MAY-94,161639,'AG',1,1,0,53.332,-105.4838,53.51317,
-105.4832,366.884,273.935,365.327,294.052,358.2,505.5,30.1,194.4,7.73,19.49,
296.74,6.2,1.92,7.49,95.27,22.0,691.3,109.9,-999.0,-999.0,487.7,-999.0,-999.0,
-999.0,1.26,368.6,32.72,-999.0,8.17,10.41,11.49,22.95,.26,.24,.2,1.33,1.34,.11,
2.9,26.4,23.7,-999.0,-999.0,38.6,-999.0,-999.0,-999.0,.37,1.3,1.39,-999.0,3.18,
4.5,4.25,7.55,-.0000216,-.0000162,.00000693,-.000113,-.00000226,-.00000639,
-.000058,.00136,.000382,-999.0,-999.0,-.0000208,.000201,.000114,-999.0,.66,
1.33,1.34,1.38,1.29,.24,.2,1.3,.78,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,
-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,-999.0,
-999.0,-999.0,-999.0,-999.0,-.06,-.22,-.22,0.0,.41,.43,.07,-.28,-999.0,.4,
-.0552,-.2169,-.2238,-.0003,73.0,156.0,2.432,-5.722,4.5,-999.0,1.134,240.0,
2455,2.87,.66,1.16,1.34,1.37,1.13,.22,.2,.6,.68,-999.0,.23,-.16,-.4,-999.0,
-999.0,.75,.61,-.08,-.15,-999.0,3.3,3.05,3.32,-999.0,-999.0,3.35,4.72,3.02,
3.43,-999.0,-.06,-.22,-.22,0.0,.45,.44,.18,-.32,-999.0,.58,-.0543,-.2169,
-.2236,-.0012,73.1,156.3,2.575,-5.708,4.5,-999.0,'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. Note that although there are fewer than 100 records in any data file, there are over 170 columns of data. Most spreadsheet software should be able to handle up to 256 columns of data.

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

The principal equations used to compute wind components and fluxes from the Twin Otter data are given in MacPherson (1990b, 1992, 1996).

9.1.1 Derivation Techniques and Algorithms

See MacPherson (1990b, 1992, 1996) and MacPherson and Bastian (1997).

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 its data before submitting the data 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 in case of 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 (1981, 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 TAS vector is then resolved into Earth axes (north, east, and vertical components). Subtracted from these are 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 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 aircraft heading.
- For each flight, the ground speed for all runs is averaged. The high-pass filtered breakpoint is then selected as the average ground speed divided by 5,000 m. This gives a breakpoint of about 0.012 Hz for high-pass filtered flux estimates.
- Three sets of fluxes were derived, one using 'raw' data, one using linearly detrended time histories, and one using high-pass filtered data. All are included in the archive, as well as correlation coefficients and RMS values of parameters contributing to the flux estimates.

9.3.2 Calculated Variables

There was no direct measurement of net radiation made on the Twin Otter in BOREAS. Rather, it was calculated at each interval using incident and reflected solar radiation (RADUP and RADOWN), with longwave contributions derived from PRT-5 surface temperature (Ts in Kelvin) and air temperature (Ta in Kelvin) in the following equation:

$$NETRAD = RADUP - RADOWN + [1.20*s*Ta^4 - 171.0] - [0.98*s*Ts^4]$$

where the last two terms represent the incident and reflected longwave components, using the Stephan-Boltzmann Constant $s = 5.6924*10^{-8}$ and a surface emissivity of 0.98. This computed value of net radiation has agreed quite well with tower measurements.

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 HP-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) for a comparison of fluxes from various aircraft.
AFM-04 submitted the following comparison table based on 1996 data.

COMPARISON BETWEEN TWIN OTTER AND FLUX TOWERS
BOREAS 1996

a) Old Aspen - SSA

Date 1996	Flight	Time *#1* [GMT]	# runs	Alt *#5*	Temp [degC]	H [W/m^2]	LE *#3* [W/m^2]	CO_2Flux *#4* [mg/m^2/s]
July 09	59	2130 2200 2120-2148	6	42	20.92 20.80 20.34	141 85 104	230 252 268 301	-0.61 -0.59 -0.71 -0.89
July 11	61	1730 1703-1730	6	36	21.60 20.59	100 75	338 306 350	-0.81 -0.78 -0.88
July 19	66	1730 1700-1720	4	46	17.86 17.40	204 138	285 266 280	-0.79 -0.80 -0.95
July 26	70	2100 2038-2103	6	32	18.95 17.95	157 84	171 214 260	-0.61 -0.81 -0.95
July 29	73	2030 2001-2025	6	34	23.23 22.19	7 10	93 154 186	-0.15 -0.36 -0.40

#1 - Lines with single time are for tower; lines with time range are for aircraft
For Aspen tower, time is for the end of the half hour period.

b) Old Black Spruce - SSA

Date 1996	Flight	Time #1 [GMT]	# runs	Alt #5	Net Rad [W/m²]	H [W/m²]	LE #3 [W /m²]	CO_2 Flux #4 [mg/m²/s]	U* [m/s]
July 10	60	1722 1702-1730	 5	 43	545 613	349 183	134 173 179	-0.25 -0.22 -0.44	0.87 0.78
July 11	61	1900 1830-1902	 6	 38	727 583	475 168	336 180 179	-0.29 -0.19 -0.39	0.61 0.62
July 20	67	1100 1044-1047	 1	 35	-33 -69	-4 -6	3 2 2	+0.04 +0.06 +0.06	0.07 0.00
July 29	72	1630 1558-1626	 5	 35	483 515	227 134	120 174 199	-0.37 -0.34 -0.53	0.30 0.33

#1 For tower, time is for end time of 1/2-hour period
#3, #4 Left From LI-COR data, right - ESRI
#5 From radar altimeter, generally above canopy
#7 Only runs used within tower half-hour

c) Old Jackpine - NSA

Date 1996	Flight	Time #1 [GMT]	# runs	Alt #5	Temp #8 [degC]	Wind [degT /mps]	H [W /m²]	LE #3 [W/m²]	CO_2 Flux #4 [mg /m²/s]	U* [m/s]
July 31	76	1700 1715-1732	 8	 29	 25.25	287/5.4 210/4.2	287 236	46 99 81	-0.19 -0.09 -0.40	0.93 0.71
Aug 02	79	 1707-1727	 8	 32	 26.03	287/7.2 227/5.6	364 197	95 90 109	-0.105 -0.07 -0.31	1.49 0.89
Aug 05	81	1558-1611 1811-1823	6 6	32 31	21.62 23.11	201/4.0 203/4.2	141 67	144 145 99 99	-0.13 -0.37 -0.11 -0.21	0.53 0.67

#1 For tower, time is for start of 1/2-hour period
#3, #4 Left From LI-COR data, right - ESRI
#5 From radar altimeter, generally above canopy
#7 Only runs used within tower half-hour
#8 Tower temperature at 30 m

d) Old Black Spruce - NSA

Date 1996	Flight	Time #1 [GMT]	# runs	Alt #5	Temp #8	Wind [degT /mps]	H [W/m²]	LE #3 [W/m²]	CO_2 Flux #4 [mg/m²/s]	U* [m/s]
July 30	75	2030 2017-2048	 6	 33	27.06 27.25	214/2.9 220/2.4	370 176	113 167 173	-0.017 -0.12 -0.31	0.29 0.42
July 31	76	1700 1650-1713	 5	 34	24.89 24.97	216/4.3 215/3.8	501 194	206 137 143	-0.22 -0.18 -0.40	0.80 0.63
Aug 02	79	1700 1642-1704	 5	 33	25.49 25.63	227/6.4 237/5.6	294 145	176 184 232	-0.26 -0.19 -0.35	0.91 0.83
Aug 03	80	1800 1830 1806-1834	 6	 32	26.35 26.76 26.66	123/3.7 135/2.8 116/3.2	420 335 203	82 195 158 171	-0.21 -0.23 -0.18 -0.39	0.56 0.61 0.54
Aug 07	82	1500 1530 1456-1514 1532-1549	 4 4	 31 34	12.16 12.66 12.88 13.48	285/3.7 283/4.1 294/4.9 289/4.3	94 84 47 86	142 103 143 181 191 209	-0.27 -0.24 -0.29 -0.50 -0.36 -0.52	0.63 0.58 0.58 0.63
Aug 08	83	1700 1645-1714	 6	 32	10.73 11.04	002/2.9 018/4.3	233 182	75 136 138	-0.30 -0.50 -0.76	0.51 0.63

#1 For tower, time is for mid time of 1/2-hour period

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

Despite careful study by Agriculture Canada technicians and some modifications to the ESRI instrument, data from 1996 suggest that the problems with the ESRI analyzer persisted.

11.3 Usage Guidance

Note that although there are fewer than 100 records in any data file, there are over 170 columns of data. Most spreadsheet software should be able to handle up to 256 columns of data.

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

The program used to generate the flux estimates for 1994 and output numerous summary files was called ARCPOK94, which was run on a MicroVAX Alpha computer used in the field and in the lab.

The program used to generate the flux estimates for 1996 and output numerous summary files for archive purposes was called ARCPOK96_NEW, which was run on the MicroVAX Alpha computer used in the field and at the Flight Research Laboratory (FRL) in Ottawa. The principal equations used to compute wind components and fluxes from Twin Otter data are given in MacPherson (1996) and MacPherson and Bastian (1997). Contact Ian MacPherson for more information.

14.2 Software Access

None given.

15. Data Access

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

15.1 Contact Information

For BOREAS data and documentation please contact:

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

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

MacPherson, J.I. 1989. NAE Twin Otter Operations in the 1988 Eulerian Model Evaluation Field Study. National Research Council Canada Report LTR-FR-107.

MacPherson, J.I. 1990a. NAE Twin Otter Operations in FIFE 1989. National Research Council Report LTR-FR-113.

MacPherson, J.I. 1990b. Wind and Flux Calculations on the NAE Twin Otter. NAE Laboratory Technical Report LTR-FR-109. National Research Council. January 1990.

MacPherson, J.I. 1992. NRC Twin Otter Operations in the 1991 California Ozone Deposition Experiment. National Research Council of Canada Report LTR-FR-118. May 1992.

MacPherson, J.I. 1996. NRC Twin Otter Operations in BOREAS 1994. Laboratory Technical Report LTR-FR-129. National Research Council Canada. April 1996.

MacPherson, J.I. and J.M. Morgan. 1981. The N.A.E. Twin Otter Atmospheric Research Aircraft. National Research Council Report LTR-FR-80.

MacPherson, J.I. and M. Bastian. 1997. NRC Twin Otter Operations in BOREAS 1996. Laboratory Technical Report LTR-FR-134. National Research Council of Canada. November 1997.

MacPherson, J.I. and S.W. Baillie. 1986. The N.A.E. Atmospheric Research Aircraft. National Research Council Report, NAE Misc. 62.

MacPherson, J.I., R.J. Grossman, and R.D. Kelly. 1992. Intercomparison Results for FIFE Flux Aircraft. Journal of Geophysical Research 97(D17):18,499-18,514.

17.2 Journal Articles and Study Reports

Barr, A.G., A.K. Betts, R.L. Desjardins, and J.I. MacPherson. 1997. Comparison of regional surface fluxes from boundary-layer budgets and aircraft measurements above boreal forest. Journal of Geophysical Research 102(D24): 29,213-29,218.

Desjardins, R.L., J.I. MacPherson, L. Mahrt, P. Schuepp, E. Pattey, H. Neumann, D. Baldocchi, S. Wofsy, D. Fitzjarrald, H. McCaughey, and D.W. Joiner. 1997. Scaling up flux measurements for the boreal forest using aircraft-tower combinations. Journal of Geophysical Research 102(D24): 29,125-29,133.

Dobosy, R.J., T.L. Crawford, J.I. MacPherson, R.L. Desjardins, R.D. Kelly, S.P. Oncley, and D.H. Lenschow. 1997. Intercomparison among four flux aircraft at BOREAS in 1994. Journal of Geophysical Research 102(D24): 29,101-29,111.

MacPherson, J.I. and A.K. Betts. 1997. Aircraft encounters with strong coherent vortices over the boreal forest. Journal of Geophysical Research 102(D24): 29,231-29,234.

MacPherson, J.I. and R.L. Desjardins. 1991. Airborne Tests of Flux Measurement by the Relaxed Eddy Accumulation Technique. Proceedings of the Seventh Symposium on Meteorological Observations and Instrumentation. American Meteorological Society. New Orleans. January, 1991.

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.

Ogunjemiyo, S., P.H. Schuepp, J.I. MacPherson, and R.L. Desjardins. 1997. Analysis of flux maps versus surface characteristics from Twin Otter grid flights in BOREAS 1994. Journal of Geophysical Research 102(D24): 29,135-29,145.

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

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

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

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

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

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

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

AES	- Atmospheric Environment Service
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
FRL	- Flight Research Laboratory
GIS	- Geographic Information System
GMT	- Greenwich Mean Time
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
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
OA	- Old Aspen
OBS	- Old Black Spruce
OJP	- Old Jack Pine
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
YA	- Young Aspen
YJP	- Young Jack Pine

20. Document Information

20.1 Document Revision Date
Written: 01-Jan-1993
Revision Date: 08-Oct-1999

20.2 Document Review Date(s)
BORIS Review: 30-Jun-1999
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:

These data were measured by the Twin Otter Atmospheric Research Aircraft operated by the National Research Council of Canada. J.I. MacPherson of NRC was the Principal Investigator responsible for the operation of the aircraft in BOREAS and the processing of the data. Other scientists on the Twin Otter project team were Ray Desjardins of Agriculture Canada and Peter Schuepp of McGill University. Funding for the Twin Otter participation in BOREAS was provided by Agriculture Canada, NSERC and the National Research Council of Canada.

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

MacPherson, J.I. and R.L. Desjardins, "Atmospheric Boundary Layer Analyses from Canadian Twin Otter Aircraft." 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:

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. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM. NASA, 2000.

20.5 Document Curator

20.6 Document URL

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	June 2000	Technical Memorandum

4. TITLE AND SUBTITLE	5. FUNDING NUMBERS
Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS) BOREAS ARM-04 Twin Otter Aircraft Flux Data	923 RTOP: 923-462-33-01
6. AUTHOR(S) J. Ian MacPherson and Raymond L. Desjardins Forrest G. Hall and David E. Knapp, Editors	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS (ES) Goddard Space Flight Center Greenbelt, Maryland 20771	**8. PEFORMING ORGANIZATION REPORT NUMBER** 2000-03136-0
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS (ES) National Aeronautics and Space Administration Washington, DC 20546-0001	**10. SPONSORING / MONITORING AGENCY REPORT NUMBER** TM—2000–209891 Vol. 6

11. SUPPLEMENTARY NOTES

J.I. MacPherson: Flight Research Laboratory, National Research Council; R.L. Desjardins: Centre for Land and Biological Resources Research, Agriculture Canada; D.E. Knapp: Raytheon ITSS

12a. DISTRIBUTION / AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Unclassified–Unlimited Subject Category: 43 Report available from the NASA Center for AeroSpace Information, 7121 Standard Drive, Hanover, MD 21076-1320. (301) 621-0390.	

13. ABSTRACT *(Maximum 200 words)*

The BOREAS AFM-4 team used the NRC Twin Otter aircraft in 1994 and 1996 to make measurements in the boundary layer of the fluxes of sensible and latent heat, momentum, ozone, methane, and carbon dioxide, plus supporting meteorological parameters such as temperature, humidity, and wind speed and direction. Aircraft position, heading, and altitude were also recorded, as were several radiometric observations for use in interpretation of the data (greenness index, surface temperature, incoming and reflected radiation). Data were collected at both the NSA and SSA during the three 1994 IFCs and in July and August of 1996. These data are stored in tabular ASCII files.

14. SUBJECT TERMS	15. NUMBER OF PAGES
BOREAS, airborne flux and meteorology.	58
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL