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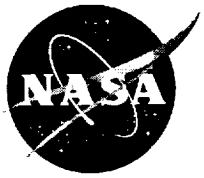

Technical Report Series on the Boreal Ecosystem-Atmosphere Study (BOREAS)

Forrest G. Hall and David E. Knapp, Editors

Volume 3

BOREAS AFM-2 Wyoming King Air 1994 Aircraft Sounding Data

R. D. Kelly

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland 20771

June 2000

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BOREAS AFM-2 Wyoming King Air 1994 Aircraft Sounding Data

Robert D. Kelly

Summary

The BOREAS AFM-2 team used the University of Wyoming King Air aircraft during IFCs 1, 2, and 3 in 1994 to collected pass-by-pass fluxes (and many other statistics) for the large number of level (constant altitude), straight-line passes used in a variety of flight patterns over the SSA and NSA and areas along the transect between these study areas. The data described here form a second set, namely soundings that were incorporated into nearly every research flight by the King Air in 1994. These soundings generally went from near the surface to above the inversion layer. Most were flown immediately after takeoff or immediately after finishing the last flux pattern of that particular day's flights. The parameters that were measured include wind direction, wind speed, west wind component (u), south wind component (v), static pressure, air dry bulb temperature, potential temperature, dewpoint, temperature, water vapor mixing ratio, and CO_2 concentration. Data on the aircraft's location, attitude, and altitude during data collection are also provided. These data are stored in tabular ASCII files.

Table of Contents

1. Data Set Overview

1.1 Data Set Identification

BOREAS AFM-02 Wyoming King Air 1994 Aircraft Sounding Data

1.2 Data Set Introduction

The BOReal Ecosystem-Atmosphere Study (BOREAS) Airborne Fluxes and Meteorology (AFM)-02 team used the University of Wyoming King Air aircraft during Intensive Field Campaigns (IFCs) 1, 2, and 3 in 1994 to collected pass-by-pass fluxes (and many other statistics) for the large number of level (constant altitude), straight-line passes used in a variety of flight patterns. The data

described here form a second set, namely soundings that were incorporated into nearly every research flight by the King Air in 1994. These soundings generally went from near the surface to above the inversion layer. Most were flown immediately after takeoff or immediately after finishing the last flux pattern of that particular day's flights. The parameters that were measured include wind direction, wind speed, west wind component (u), south wind component (v), static pressure, air dry bulb temperature, potential temperature, dewpoint, temperature, water vapor mixing ratio, and CO_2 concentration. Data on the aircraft's location, attitude, and altitude during data collection are also provided. These data are stored in tabular American Standard Code for Information Interchange (ASCII) files.

1.3 Objective/Purpose

The objective of this data set is to add to the set of soundings represented by the network of rawinsondes launched during the project.

1.4 Summary of Parameters

The following is a simple list of the variables archived for each sounding by the King Air. Section 7 defines the variables and their origins in detail. Those variables flagged (**) were not measured by the King Air.

VARIABLES:

- BOREAS aircraft i.d.
- 20-character aircraft descriptor
- Date
- BOREAS mission designator
- Start time, Greenwich Mean Time (GMT)
- End time
- Starting latitude
- End latitude
- Starting longitude
- End longitude
- Starting BOREAS Information System (BORIS) grid E
- End BORIS grid E
- Starting BORIS grid N
- End BORIS grid N

There is one line of data for each second of sounding data. For data collected at rates greater than 1 Hz, the entry is a 1-second average:

- Time, GMT
- Latitude
- Longitude
- Pressure altitude
- Radar altitude
- Aircraft heading
- Wind direction
- Wind speed
- West wind component, u
- South wind component, v
- Static pressure
- Air dry bulb temperature
- Potential temperature
- Dewpoint temperature
- Water vapor mixing ratio
- CO2 concentration
- Ozone concentration **

1.5 Discussion

The King Air was flown in all three IFCs in 1994. These archived sounding data were collected primarily over the two BOREAS study areas and occasionally on regional runs between the Southern Study Area (SSA) and the Northern Study Area (NSA). The high-rate data from which all these variables were computed were not submitted to BORIS. If required, they may be acquired from the University of Wyoming directly.

1.6 Related Data Sets

Related data sets include the King Air flux data for BOREAS-94 and the flux and/or sounding archives from the other three flux aircraft (AFM-01, AFM-03, AFM-04). Other related data sets include soundings from rawinsondes (AFM-05) launched during corresponding dates.

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 and Moving Window Data
BOREAS AFM-03 NCAR Electra 1994 Aircraft Sounding Data
BOREAS AFM-04 NRC Twin Otter Aircraft Flux 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

2. Investigator(s)

2.1 Investigator(s) Name and Title

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2.2 Title of Investigation

Airborne Investigation of Biosphere-Atmosphere Interactions over the Boreal Forest

2.3 Contact Information

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3. Theory of Measurements

The theory and practice of measuring atmospheric variables from a moving, aircraft platform have been discussed by many researchers. A series of introductory monographs addressing those topics may be found in Lenschow (1986).

Briefly, the aircraft uses gust sensors to measure the 3-D air motion relative to the aircraft and a combination of an inertial platform, accelerometers, and (more recently) a satellite-based global positioning system (GPS) to measure the motion of the aircraft relative to Earth. These data are combined to determine aircraft position and the Earth-relative 3-D winds. Scalar quantities, including static pressure, temperature, water vapor mixing ratio, and CO_2 mixing ratio are also measured with fast-response, aircraft-mounted sensors.

4. Equipment

4.1 Sensor/Instrument Description

Table of University of Wyoming King Air Instruments

Variable	Instrument	Accuracy	Resolution
Hi-rate temperature	Rosemount housing, fast-response thermistor (design by Friehe, UCI)	0.50 C	0.01 C
Dewpoint temperature	Cambridge Model 1373C	1.0 C, >0 C	0.006 C
Water vapor mix ratio	LICOR 6262 IR spectrometer	1% of reading	0.001 g/kg
CO_2 mix ratio	LICOR 6262 IR spectrometer	+/-1ppm at .01 ppm	350 ppm
Magnetic heading	King KPI553/Sperry C14-43	1 degree	0.02 degree
Static pressure	Rosemount 1201FA1B1A	0.5 mb	0.06 mb
Static pressure	Rosemount 1501	0.5 mb	0.003 mb
Geometric Altitude	Stewart Warner APN159	1% reading	0.24 ft
Geometric Altitude	King KPA 405	3% <500 ft 6% > 500 ft	0.48 ft
Total pressure	Rosemount 831CPX	2 mb	0.005 mb
Azimuth VOR	King KNR615 VOR	1 degree	0.02 degree
Distance DME	King KNR705A DME	0.2 nautical miles	0.1 nautical mile
Latitude/longtitude	Tremble 2000 GPS	100 m	0.000172 degree
Latitude/longtitude	Honeywell Laseref SM	0.8 nm/hr drift	0.000172 degree
Ground velocity	Honeywell Laseref SM	13.5 ft/s	0.0039 kts
Vertical velocity	Honeywell Laseref SM	0.5 ft/s	0.03215 ft/min
Pitch/roll	Honeywell Laseref SM	0.05 degree	0.000172 degree
Platform heading	Honeywell Laseref SM	0.2 degree	0.000172 degree
Flow angle	Rosemount 858AJ/831CPX	0.2 degree	0.00375 degree
Vertical acceleration	Humphrey SA0905021	0.002 g	0.0001 g
Rate of climb	Rosemount 1241A4BCDE	1%, <15000 ft 2%, >25000 ft	0.004 m/s
Engine torque	--	--	0.2 ft-lbf
Liquid Water Content	In-house CSIRO hot wire	0.2 g/m^3	0.0003 g/m^3
Liquid Water Content	Bacharach LWH	0.2 g/m^3	0.0002 g/m^3
Cloud drops	PMS FSSP	3 micron	3 micron
Radiation:			
Upwelling Shortwave (0.3-3 microns)	Eppley Pyranometer	5 W/m^2	1 W/m^2
Downwelling Shortwave	Eppley Pyranometer	5 W/m^2	1 W/m^2

(0.3-3 microns)			
Upwelling IR (4-50 microns)	Eppley Pyrgeometer	15 W/m^2	1 W/m^2
Downwelling IR (4-50 microns)	Eppley Pyrgeometer	15 W/m^2	1 W/m^2

4.1.1 Collection Environment

The data were collected at the beginning and end of each day's flights over a vertical range with varying atmospheric conditions.

4.1.2 Source/Platform

Platform: Beechcraft Super King Air model 200T, twin-turboprop aircraft.

4.1.3 Source/Platform Mission Objectives

See Section 1.4.

4.1.4 Key Variables

See Sections 1.4, 1.5, and 7.3.

4.1.5 Principles of Operation

See Section 3.

4.1.6 Sensor/Instrument Measurement Geometry

The gust probe was mounted at the end of the aircraft nose boom, so that the gust probe tip was about 2 m ahead of the nose of the aircraft. The inertial reference system (IRS) and accelerometers were mounted close to the main wing spar (close to aircraft's center of gravity). The fast-response (Friehe-type) temperature probe was mounted below the nose of the aircraft, 1.29 m aft from the gust probe tip. Water vapor and CO_2 measurements were obtained with the LI-COR 6262 infrared absorption spectrometer. Air was drawn from the airstream above the aircraft cabin into a 12.7-mm i.d. "snorkel" tube that faced forward, about 0.3 m above the fuselage skin and 4.06 m aft of the gust probe tip. Airflow in the snorkel tube was maintained with a high-capacity vacuum pump at 60-70 SLPM (about 9 m/s), for Reynolds number about 50,000 (fully developed turbulent flow). At 1.52 m from the inlet, air was drawn from the center of the snorkel tube into the LI-COR through a short 6.4-mm i.d. tube, again by vacuum pump, at an average flow rate of 6-8 SLPM (also fully turbulent). As verified by flying the aircraft through a power-plant plume, there was a time delay of 0.3 s between the gust probe data and the LI-COR data. This delay is removed in the software at the time of data processing.

Further notes on LI-COR operation: The LI-COR 6262 was operated in "absolute" mode, in which the closed-path absorption in the sample chamber was simultaneously compared to the closed-path absorption in the reference chamber. Air in the reference chamber was circulated continuously through scrubbers that removed both water and CO_2, and was circulated at a flow rate of 2 SLPM. A Cambridge chilled-mirror dewpoint hygrometer was mounted inside the cabin, drawing air from the vacuum-pump driven sample tube. All cloud and precipitation probes (PMS and liquid water content) were mounted near the wing tips of both wings.

4.1.7 Manufacturer of Sensor/Instrument

See table in Section 4.1

4.2 Calibration

The instruments were subject to calibration as follows:

- **Air temperature:** The manufacturer's one-time calibration was used for the Rosemount model 102, and the Friehe-type probe was then compared against the Rosemount.
- Water vapor concentration: Before each flight, the LI-COR H_2O channel was calibrated by flushing the chamber with a beam-filling gas of known H_2O concentration, generated with a LI-COR Model 610 dewpoint generator, with accuracy +/-0.03 °C.

- **CO_2 concentration:** Before each flight, the LI-COR CO_2 channel was calibrated by flushing the chamber with a gas of known CO_2 concentration (Source: Scott Specialty, Longmont, CO, concentration 403.5 ppm, accurate to 4%).
- **Static pressure and gust differential pressures:** The gust probe differential pressure sensors (for up-down and left-right angle of flow measurements) and absolute pressure sensor (gust probe total pressure) were calibrated at the beginning of each IFC, using the Rosemount 1501 (accurate to 0.5 mb).

4.2.1 Specifications
See table in Section 4.1.

4.2.1.1 Tolerance
See table in Section 4.1.

4.2.2 Frequency of Calibration
See Section 4.2.

4.2.3 Other Calibration Information
None given.

5. Data Acquisition Methods

Whenever possible, the soundings were executed at a relatively slow rate of ascent or descent (about 500 feet per minute). Some, however, were flown at faster rates (see data for each sounding to ascertain rate).

6. Observations

6.1 Data Notes
None.

6.2 Field Notes
None.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage
These data cover various point locations within the SSA and NSA and areas along the transect between these study areas. The majority of the data were collected over the BOREAS SSA and NSA.

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

	Latitude	Longitude
Northwest	54.321° N	106.228° W
Northeast	54.225° N	104.237° W
Southwest	53.515° N	106.321° W
Southeast	53.420° N	104.368° W

The NAD83 corner coordinates of the NSA are:

	Latitude	Longitude
Northwest	56.249° N	98.825° W
Northeast	56.083° N	97.234° W
Southwest	55.542° N	99.045° W
Southeast	55.379° N	97.489° W

7.1.2 Spatial Coverage Map

Data were collected over the NSA and SSA of BOREAS, and along a transect between them.

7.1.3 Spatial Resolution

Each sounding occupied a finite horizontal distance, which can be ascertained from the location information included in the data.

7.1.4 Projection

These data represent point measurements.

7.1.5 Grid Description

None.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

Times of data collection are contained in the table below. See Section 5 for flight pattern descriptions.

Table of UW King Air Research Flights for BOREAS 1994

Date	Start	End	Hrs	Weather	Description and comments
940525	1745	2000	2.9	5-10% sct cu	CS, 2 rts a-h, 300 agl FS, first a-h with FE
940526	1646	1905	3.0	ci, small % cu	GS, full rt, 300 agl
940531	1645	1929	3.6	cu incr 10-40% sharp jump Zi	FS, 300 agl with FT PS, using W,E ends FK grid at 200 agl, 2500 and 3400 msl FS, a-d, 300 agl, with FE
940601	630	1802	2.4	H, ci, cist sct cu < 1%	LS, j-i-h-i-j, 200 agl CS, one rt d-a-d, 200 agl
940604	1616	1919	3.8	clr then cu incr rapidly, end ovc	CS, mult passes 200 agl, 3000 msl FS, d-a, 200 agl, with FL
940606	1546	1809	3.1	cu < 5%	LS, mult h-i-j, 200 agl-2900 msl
940607	1447	1649	4.8	clr entire pattern	RT, a-h-k-l-m, 200 agl
	1649	1904		clr entire pattern	GN, full rt, all 300 agl, EW lines
940608	1520	1742	2.9	clr	LN, mult t-o at 200 agl, 2100 msl FN, m-o, 300 agl with FT
940610	1642	1901	3.0	sct ci, K all sky	GN, full rt, 200 agl, NS lines
940611	1646	1844	2.6	K, cu to 80%, RW-	RT, o-m-l-k-h-a, 200 agl
940720	1656	2044	4.4	H, K, cu 10-50%	CS, a-d, 300 agl to 4800 msl (co-ord with FE) FS, two a-d, 300 agl with FE
940721	1652	1905	3.0	clr?	GS, full rt, 200 agl, NS lines FS, one run SW of grid with FT
940723	1528	1800	3.2	clr, incr to 20% cu	CS, mult a-d at 200 agl, 3500 msl
940724	1655	1943	3.4	clr over site	GS, full rt, 200 agl, EW lines

Date	Start	End	Hrs	Weather	Description and comments
940725	1519	1753	3.2	clr	CS, mult a-d at 200 agl, 3000 msl
940726	1628	1832	2.7	K, ci	RT, a-h-k-l-m-o, 200 agl
940727	1609	1909	4.3	K, altocu, cu	GN, full rt 200 agl, NS lines TN (mult) at radar, 500-1000 agl
940728	1620	1810	2.6	K, ci	HN(GN) time-centered m-o, 200 agl, 1800 and 2700 msl
940731	1550	1859	3.7	K, clr above	GN
940831	1720	1938	2.9	K, cu <1 to 40%	GN, full rt, 200 agl, EW lines
940901	1550	1717	1.9	clr above K	FN, rt 200 agl, with FT FN, rt 200 agl, diff TAS than FT LN, o-m-o-m-o, 200 agl
940903	1548	1811	3.0	ci, K, cu 0-10%	GN, full rt, 200 agl, EW lines
940906	1605	1833	2.9	cu 20-80%	GN, full rt, 200 agl, NS lines
940908	1606	1823	2.8	acu, ci, cist, ci ovc	RT, o-m-l-k-h-a, 200 agl
940909	1940	2131	2.7	ci, cist thinning	CS, mult 200 agl-2600 msl, with FE FS, 300 agl, with FE
940912	1735	2004	3.6	cu incr 0-30%	CS, 3 rts, all 200 agl Test = 3 rt over OA area of CS
940913	1645	1905	3.4	clr, then cist and ci	GS, full rt, 200 agl, EW lines Test = wind "L" at 8500 msl
940916	1653	1914	4.8	clr	GS, full rt, NS lines, 200 agl
	1925	2053		clr then <5% cu	CS, d-a mult lvls, with FE FS, second a-d with FE, 600 agl
940917	1712	1902	2.4	clr, thin ci to W	FS, one end=a, 200 agl, with FT CS, a-d, two rts, 200 agl

Abbreviations used for flight patterns:

```
ID      Description (second letter denotes NSA or SSA).
CS      Candle Lake runs, SSA only, usually along path a-d.
FS,FN   Flights of two (intercomparison runs), various locns.
GS,GN   Grid patterns.  Sequence of 9 evenly spaced, parallel
        flight lines, covering a 32-x 32-km square area (King Air),
        with lines oriented either east-west or north-south.
HS,HN   Stack patterns.
LS,LN   Transects of intermediate length (e.g., 100 km).
PS,PN   Budget box pattern (see Betts et al., 1990b).
RT      Regional transect.  For King Air, route used in
        transit between NSA and SSA.  Coincides with Electra RTs.
TS,TN   Site-specific run at a TF (tower flux) site.
```

Abbreviations used in weather notes in table:

```
cu     cumulus
st     status
ci     cirrus
sct    scattered
Zi     inversion height above ground
H      haze
K      smoke
cist   cirrostratus
clr    clear
ovc    overcast
RW-    light rain showers
acu    altocumulus
```

Abbreviations in flight descriptions:

```
rt     round trip
agl    above ground level (in feet)
msl    above mean sea level (in feet)
mult   multiple
TAS    true airspeed
lvl    level
wind "L"  "L" with one leg parallel to wind
       direction, flown as at least one round trip
```

7.2.2 Temporal Coverage Map

None.

7.2.3 Temporal Resolution

See Section 7.2.1. Also, each archived data entry contains the time for the sounding being summarized.

7.3 Data Characteristics

7.3.1 Parameter/Variable

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

```
          Column Name
------------------------------
SPATIAL_COVERAGE
DATE_OBS
TIME
FLUX_MISSION_DESIGNATOR
LATITUDE
LONGITUDE
BOREAS_X
BOREAS_Y
PRESS_ALT
RADAR_ALT
HEADING
WIND_DIR
WIND_SPEED
U_COMPNT_WIND_VELOC
V_COMPNT_WIND_VELOC
```

ATMOSPHERIC_PRESS
DRY_BULB_TEMP
POTENT_TEMP
DEWPOINT_TEMP
MIXING_RATIO_AFM
CO2_CONC
O3_CONC
CRTFCN_CODE
REVISION_DATE

7.3.2 Variable Description/Definition

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

Column Name	Description
SPATIAL_COVERAGE	The general term used to denote the spatial area over which the data were collected.
DATE_OBS	The date on which the data were collected.
TIME	The Greenwich Mean Time (GMT) when the data were collected.
FLUX_MISSION_DESIGNATOR	The two-letter mission identifier used to identify the type of mission being flown, where GS or GN=grids and stacks, CS=Candle Lake runs, TS or TN=site-specific runs, RT=transects, LS or LN=mini- or meso-transects, PS or PN=Budget Box pattern, HS or HN=stacks and tees, FS or FN=flights of two for intercomparison, ZS=low-level routes, and XX=not standard.
LATITUDE	The NAD83-based latitude coordinate at the site.
LONGITUDE	The NAD83-based longitude coordinate at the site.
BOREAS_X	The x component of the BOREAS grid coordinate at the site.
BOREAS_Y	The y component of the BOREAS grid coordinate at the site.
PRESS_ALT	The measured pressure altitude.
RADAR_ALT	The measured radar altitude.
HEADING	The aircraft heading.
WIND_DIR	The direction from which the wind was traveling, increasing in a clockwise direction from north.
WIND_SPEED	The wind speed.
U_COMPNT_WIND_VELOC	The westerly (from the west) vector component of the wind speed and wind direction.
V_COMPNT_WIND_VELOC	The southerly (from the south) vector component of the wind speed and wind direction.
ATMOSPHERIC_PRESS	The atmospheric pressure.
DRY_BULB_TEMP	The temperature measured from the dry-bulb thermometer.
POTENT_TEMP	The computed potential temperature.
DEWPOINT_TEMP	The measured dewpoint temperature.
MIXING_RATIO_AFM	The calculated mixing ratio.
CO2_CONC	CO2 concentration.
O3_CONC	The measured ozone concentration.
CRTFCN_CODE	The BOREAS certification level of the data.

	Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).
REVISION_DATE	The most recent date when the information in the referenced data base table record was revised.

7.3.3 Unit of Measurement

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

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

7.3.4 Data Source

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

Column Name	Data Source
SPATIAL_COVERAGE	[Assigned by BORIS.]
DATE_OBS	[Supplied by Investigator.]
TIME	[Supplied by Investigator.]
FLUX_MISSION_DESIGNATOR	[Supplied by Investigator.]
LATITUDE	[Supplied by Investigator.]
LONGITUDE	[Supplied by Investigator.]
BOREAS_X	[Supplied by Investigator.]
BOREAS_Y	[Supplied by Investigator.]
PRESS_ALT	[Supplied by Investigator.]
RADAR_ALT	[Supplied by Investigator.]
HEADING	[Supplied by Investigator.]
WIND_DIR	[Supplied by Investigator.]
WIND_SPEED	[Supplied by Investigator.]

U_COMPNT_WIND_VELOC	[Supplied by Investigator.]
V_COMPNT_WIND_VELOC	[Supplied by Investigator.]
ATMOSPHERIC_PRESS	[Supplied by Investigator.]
DRY_BULB_TEMP	[Supplied by Investigator.]
POTENT_TEMP	[Supplied by Investigator.]
DEWPOINT_TEMP	[Supplied by Investigator.]
MIXING_RATIO_AFM	[Supplied by Investigator.]
CO2_CONC	[Supplied by Investigator.]
O3_CONC	[Supplied by Investigator.]
CRTFCN_CODE	[Assigned by BORIS.]
REVISION_DATE	[Assigned by BORIS.]

7.3.5 Data Range

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

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SPATIAL_COVERAGE	N/A	N/A	None	None	None	None
DATE_OBS	25-MAY-94	17-SEP-94	None	None	None	None
TIME	143600	213630	None	None	None	None
FLUX_MISSION_ DESIGNATOR	SN	SN	None	None	None	None
LATITUDE	53.2171	56.1223	None	None	None	None
LONGITUDE	-106.551	-97.7009	None	None	None	None
BOREAS_X	294.792	821.222	None	None	None	None
BOREAS_Y	260.055	649.007	None	None	None	None
PRESS_ALT	205	3472	None	None	None	None
RADAR_ALT	42.2	762.7	None	None	None	None
HEADING	.2	359.9	None	None	None	None
WIND_DIR	0	360	None	None	None	None
WIND_SPEED	.1	23.7	None	None	None	None
U_COMPNT_WIND_VELOC	-17.45	20.43	None	None	None	None
V_COMPNT_WIND_VELOC	-20.85	16.56	None	None	None	None
ATMOSPHERIC_PRESS	66	98.88	None	None	None	None
DRY_BULB_TEMP	-6.32	25.94	None	None	None	None
POTENT_TEMP	285.52	313.34	None	None	None	None
DEWPOINT_TEMP	-26.4	15.4	None	None	None	None
MIXING_RATIO_AFM	.59	11.98	None	None	None	None
CO2_CONC	308.3	778.4	None	None	None	None
O3_CONC			-999	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None
REVISION_DATE	05-AUG-96	02-MAR-99	None	None	None	None

Minimum Data Value -- The minimum value found in the column.
Maximum Data Value -- The maximum value found in the column.
Missng Data Value -- The value that indicates missing data. This is used to indicate that an attempt was made to determine the parameter value, but the attempt was unsuccessful.
Unrel Data Value -- The value that indicates unreliable data. This is used to indicate an attempt was made to determine the parameter value, but the value was deemed to be

```
                    unreliable by the analysis personnel.
Below Detect Limit -- The value that indicates parameter values below the
                    instruments detection limits.  This is used to
                    indicate that an attempt was made to determine the
                    parameter value, but the analysis personnel determined
                    that the parameter value was below the detection
                    limit of the instrumentation.
Data Not Cllctd    -- This value indicates that no attempt was made to
                    determine the parameter value.  This usually
                    indicates that BORIS combined several similar but
                    not identical data sets into the same data base table
                    but this particular science team did not
                    measure that parameter.

Blank -- Indicates that blank spaces are used to denote that type of value.
N/A   -- Indicates that the value is not applicable to the respective column.
None  -- Indicates that no values of that sort were found in the column.
-------------------------------------------------------------------------------
```

7.4 Sample Data Record

The following are wrapped versions of data records from a sample data file on the CD-ROM.

```
SPATIAL_COVERAGE,DATE_OBS,TIME,FLUX_MISSION_DESIGNATOR,LATITUDE,LONGITUDE,
BOREAS_X,BOREAS_Y,PRESS_ALT,RADAR_ALT,HEADING,WIND_DIR,WIND_SPEED,
U_COMPNT_WIND_VELOC,V_COMPNT_WIND_VELOC,ATMOSPHERIC_PRESS,DRY_BULB_TEMP,
POTENT_TEMP,DEWPOINT_TEMP,MIXING_RATIO_AFM,CO2_CONC,O3_CONC,CRTFCN_CODE,
REVISION_DATE
'SSA',04-JUN-94,192036,'SN',53.93776,-104.764,408.602,345.178,610.3,76.3,222.9,
156,2.2,-.87,1.97,94.2,21.1,299.31,6.1,6.28,348.9,-999.0,'CPI',05-AUG-96
'SSA',04-JUN-94,192037,'SN',53.93756,-104.764,408.604,345.156,611.1,74.2,222.8,
147,1.9,-1.06,1.58,94.2,21.09,299.31,6.2,6.35,349.1,-999.0,'CPI',05-AUG-96
```

8. Data Organization

8.1 Data Granularity

The smallest orderable data set available is the one of two files of soundings for a day.

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

None.

9.1.1 Derivation Techniques and Algorithms

None given.

9.2 Data Processing Sequence

9.2.1 Processing Steps

- AFM-02 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.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

Time lag between CO_2/H_2O measurements and gust probe:

Due to the geometry of the instrument locations (see Section 4.1.6), there is a significant lag between measurements by the LI-COR device (water vapor and carbon dioxide) and the 3-D winds. Based on instrument placement, external airflow velocities, and internal (sampling tubes) flow velocities, the lag was predicted to be 0.3 sec. In contrast, the distance between the gust probe tip and the Friehe temperature probe caused negligible lag between the temperature and wind measurements. Thus, the lag between the temperature and LI-COR measurements should be equivalent to that between the wind and LI-COR measurements. The predicted temperature-LI-COR lag (0.3 sec) was verified by flying the plane several times through the plume from a local power plant, at distances close enough to the source that changes in temperature, water vapor, and CO_2 were very abrupt at the plume edges. Thus, prior to any other calculations, the LI-COR data are shifted 0.3 sec, to bring those data in sync with the remainder of the data.

9.3.2 Calculated Variables

None given.

9.4 Graphs and Plots

None.

10. Errors

10.1 Sources of Error

See Section 11.2 for a description of instrument limits.

10.2 Quality Assessment

An extensive intercomparison of the BOREAS flux aircraft has been written and published by Dobosy et al. (1997). In that text, King Air measurements, including means and variances of all the flux variables, as well as the fluxes themselves, are compared with corresponding values from the Canadian National Research Council (NRC) Twin Otter and the National Center for Atmospheric Research (NCAR) Electra, for multiple wing-to-wing passes at various times during the 1994 experiment. As of this writing, these comparisons are the best available assessments of the overall data quality for the King Air, at least in comparison with similarly instrumented platforms.

10.2.1 Data Validation by Source

None.

10.2.2 Confidence Level/Accuracy Judgment

The data are considered to be reasonably accurate. See Section 11.2 for description of possible problems.

10.2.3 Measurement Error for Parameters

See table in Section 4.1.

10.2.4 Additional Quality Assessments

None.

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

Vertical velocity measurements:

Spectral density plots of vertical velocity (w) generally show a fairly well defined inertial subrange, with -5/3 slope out to about 9 Hz, at which point the effects of the anti-aliasing low-pass filter are evident. Many of the w spectral plots do, however, show a slight "bulge" above the -5/3 line in the range 0.1-1 Hz. As of this writing (09-Jul-1996), we believe this is an artifact of the postflight calculations. Examples of these spectra can be seen in Dobosy et al. (1997).

High-rate H_2O measurements (LI-COR 6262):

The LI-COR 6262 response is described by the manufacturer as being a 90% response to step-function changes in concentration in 0.1 s. The combination of this characteristic, any along-flow mixing in the sample tubes, and the anti-aliasing filter is evident in the spectral density plots for H_2O mixing ratio. These plots generally show an inertial subrange (slope -5/3) out to about 2 Hz, at which point the response drops sharply. At 2 Hz, the signal-to-noise ratio (SNR) is usually about 20 dB. Implications of this response for the flux calculations are that the H_2O fluxes are being resolved only to about 2 Hz (about 40 m for typical research airspeeds).

CO_2 measurements (LI-COR 6262):

The response characteristics for CO_2 are generally the same as for H_2O, except that the SNR at 2 Hz is usually 10 dB or less. As with CO_2, these figures imply that the CO_2 fluxes are being resolved only to about 2 Hz (about 40 m for typical research airspeeds).

11.3 Usage Guidance

None given.

11.4 Other Relevant Information

None.

12. Application of the Data Set

This data set can be used to understand the change in CO_2 concentration with altitude, which can in turn be used to infer fluxes.

13. Future Modifications and Plans

None given.

14. Software

14.1 Software Description

None given.

14.2 Software Access

None given.

15. Data Access

The Wyoming King Air 1994 aircraft sounding 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

See references listed in Section 17.2.

17.2 Journal Articles and Study Reports

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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

Abbreviations used in weather notes:

cu	cumulus
st	status
ci	cirrus
sct	scattered
Zi	inversion height above ground
H	haze
K	smoke
cist	cirrostratus
clr	clear
ovc	overcast
RW-	light rain showers
acu	altocumulus

Abbreviations in flight descriptions:

rt	round trip
agl	above ground level (in feet)
msl	above mean sea level (in feet)
mult	multiple
TAS	true airspeed
lvl	level
wind "L"	"L" with one leg parallel to wind direction, flown as at least one round trip

19. List of Acronyms

AFM	- Airborne Fluxes and Meteorology
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
EOS	- Earth Observing System
EOSDIS	- EOS Data and Information System
GIS	- Geographic Information System
GMT	- Greenwich Mean Time
GPS	- Global Positioning System
GSFC	- Goddard Space Flight Center
HTML	- HyperText Markup Language
IFC	- Intensive Field Campaign
IRS	- Inertial Reference System
NASA	- National Aeronautics and Space Administration
NCAR	- National Center for Atmospheric Research
NRC	- National Research Council, Canada
NSA	- Northern Study Area
ORNL	- Oak Ridge National Laboratory
PANP	- Prince Albert National Park
SA	- Study Area
SNR	- Signal to Noise Ratio
SSA	- Southern Study Area
URL	- Uniform Resource Locator

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13. ABSTRACT *(Maximum 200 words)*

The BOREAS AFM-2 team used the University of Wyoming King Air aircraft during IFCs 1, 2, and 3 in 1994 to collected pass-by-pass fluxes (and many other statistics) for the large number of level (constant altitude), straight-line passes used in a variety of flight patterns over the SSA and NSA and areas along the transect between these study areas. The data described here form a second set, namely soundings that were incorporated into nearly every research flight by the King Air in 1994. These soundings generally went from near the surface to above the inversion layer. Most were flown immediately after takeoff or immediately after finishing the last flux pattern of that particular day's flights. The parameters that were measured include wind direction, wind speed, west wind component (u), south wind component (v), static pressure, air dry bulb temperature, potential temperature, dewpoint, temperature, water vapor mixing ratio, and CO_2 concentration. Data on the aircraft's location, attitude, and altitude during data collection are also provided. These data are stored in tabular ASCII files.

14. SUBJECT TERMS
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