Aircraft Flux - Filtered: NRCC (FIFE)

Summary:

The purpose of this study was to develop alternatives to ground-based measurements in order to obtain information required to predict the effects of soil and land use on the fluxes of greenhouse gases, the surface energy balance, and the water balance. Satellite-based algorithms have been developed via flux measurements from an aircraft to estimate vegetation and soil conditions on a regional scale. The purpose of the Twin Otter FIFE flights was to make measurements in the boundary layer of the fluxes of sensible and latent heat, momentum, and carbon dioxide, plus supporting meteorological parameters such as temperature, humidity, wind speed, and direction. Aircraft position, heading, and altitude were also recorded, as were several radiometric observations for use in interpretation of these data. The Twin Otter aircraft allows steady flight trajectories at low airspeed (50-60 [m][sec^-1]) down to levels less than 10 m above the ground. The aircraft is instrumented to measure the contribution of flux densities of momentum, sensible, and latent heat, and CO2 over a frequency range of 0 to 5 Hz (MacPherson et al., 1981).

All the flux measurements were obtained with the eddy-correlation method, wherein the aircraft is equipped with an inertial platform, accelerometers, and a gust probe for measurement of earth-relative gusts in the x, y, and z directions. Gusts in these dimensions are then correlated with each other for momentum fluxes and with fluctuations in other variables to obtain the various scalar fluxes, such as temperature (for sensible heat flux) and water vapor mixing ratio (for latent heat flux). The fluctuations in all variables were calculated with three different methods (the arithmetic means removed, the linear trends removed, or filtered with a high-pass recursive filter) prior to the eddy correlation calculations. This data set contains data that were high-pass filtered with a third order algorithm with a break point set at 0.012 Hz (5 km wavelength).

Through this research, it is hoped that techniques can be developed to utilize satellite data for global monitoring of crop health and climate change

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Aircraft Flux - Filtered: NRCC (FIFE).
(Filtered Boundary Layer Fluxes from the Twin Otter).

Data Set Introduction:

The purpose of this study was to make measurements in the boundary layer of the fluxes of sensible and latent heat, momentum, and carbon dioxide, plus supporting meteorological parameters such as temperature, humidity, wind speed, and direction. The data set includes run-averaged data, focusing on the fluxes and the supporting meteorological, radiometric, and aircraft positional data.

Objective/Purpose:

The Twin Otter was one of three flux aircraft operated in FIFE. The purpose of its flights was to make measurements in the boundary layer of the fluxes of sensible and latent heat, momentum, and carbon dioxide, plus supporting meteorological parameters such as temperature, humidity, wind speed, and direction. Aircraft position, heading, and altitude were also recorded, as were several radiometric observations for use in interpretation of these data (greenness index, surface temperature, and 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 crop health and climate change

Summary of Parameters:

Temperature, dew point temperature, pressure, downwelling radiation, upwelling radiation, greenness index, three orthogonal components of the wind velocity, along-wind component, across-wind component, water mixing ratio, carbon dioxide mixing ratio, sensible heat flux, latent heat flux, momentum flux, carbon dioxide flux, aircraft position, heading, altitude (radar and pressure), and surface temperature.

Discussion:

The Twin Otter flew 58 project flights in FIFE: 42 in 1987 and 16 in 1989. The archived data were collected on straight and level flux runs over the FIFE study area and on regional runs between Salina and the FIFE project area. There were a variety of flight profiles (grids, L-patterns, profiling stacks, soundings), which are described in the FIFE Experiment Plans and Reports (see the *Journal Articles and Study Reports Section*). The archive data include run-averaged data, focusing on the fluxes and the supporting meteorological, radiometric, and aircraft positional data. No attempt has been made to archive the high-rate (16 Hz) data, which can be acquired from NRC directly, if required. MacPherson (1988, 1990a) gives a complete description of the Twin Otter's participation in FIFE; the 1989 report also includes tables of the run-averaged data.

Related Data Sets:

- Detrended Atmospheric Turbulence Data from the NCAR King Air.
- Filtered Atmospheric Turbulence Data from the NCAR King Air.
- Raw Atmospheric Turbulence Data from the NCAR King Air.
- Detrended Boundary Layer Fluxes from the Twin Otter.
- Raw Boundary Layer Fluxes from the Twin Otter.
- Detrended Boundary Layer Fluxes from the UW King Air.
- Filtered Boundary Layer Fluxes from the UW King Air.
- Raw Boundary Layer Fluxes from the UW King Air.
- Eddy Correlation Surface Flux Observations (USGS).
- Eddy Correlation Surface Flux Observations (UNL).
- Eddy Correlation Surface Flux Observations (GSFC).
- Eddy Correlation Surface Flux Observations (UK).
- Eddy Correlation Surface Flux Observations (Argonne).
- Bowen Ratio Surface Flux Observations (GSFC).
- Bowen Ratio Surface Flux Observations (KSU).
- Bowen Ratio Surface Flux Observations (Fritschen).
- Bowen Ratio Surface Flux Observations (UNL).
- Bowen Ratio Surface Flux Observations (USGS).
- Bowen Ratio Surface Flux Observations (Smith).
- FIFE Radiosonde Data.
- FIFE Standard Pressure Level Radiosonde Data.
- FIFE Radiosonde Wind Profiles.
- FIFE Temperature and Humidity Profiles.
- Quick Look Boundary Layer Height.
- Boundary Layer Heights Using SODAR.
- NOAA Radiosonde Observations.
- UW Boundary Layer Winds and Clouds. (Imagery Data)

FIS Data Base Table Name:

AIRCRAFT_FLUX_DATA_FILTERED.

2. Investigator(s):

Investigator(s) Name and Title:

J. Ian MacPherson
National Research Council of Canada

Title of Investigation:

Atmospheric Boundary Layer Analyses from Canadian Twin Otter Aircraft.

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Requested Form of Acknowledgment.

The National Aeronautical Establishment (NAE) Twin Otter Atmospheric Research Aircraft was 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 FIFE and the processing of the atmospheric boundary layer 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 FIFE was provided by NASA and by the National Research Council of Canada.

3. Theory of Measurements:

Most ecosystems are not homogeneous and point measurements are frequently not representative of processes such as mass and energy transfer, which on a large scale, play an important role in affecting environmental conditions (Desjardins et al., 1990). It is therefore important to develop alternatives to ground-based measurements in order obtain information required to predict the effects of soil and land use on the fluxes of greenhouse gases, the surface energy balance, and the water balance. Hence, flux measurements from an aircraft (Desjardins et al., 1985; Schuepp et al., 1987; Lenschow et al., 1982) have been used for calculation of satellite-based algorithms to estimate vegetation and soil conditions on a regional scale. The Twin Otter aircraft allows steady flight trajectories at low airspeed (50 - 60 [m][sec^-1]) down to levels less than 10 m above the ground. The aircraft is instrumented to measure the contribution of flux densities of momentum, sensible, and latent heat, and CO_2 over a frequency range of 0 to 5 Hz (MacPherson et al., 1981).

All the flux measurements were obtained with the eddy-correlation method, wherein the aircraft is equipped with an inertial platform, accelerometers, and a gust probe for measurement of earth-relative gusts in the x, y, and z directions. Gusts in these dimensions are then correlated with each other for momentum fluxes and with fluctuations in other variables to obtain the various scalar fluxes, such as temperature (for sensible heat flux) and water vapor mixing ratio (for latent heat flux). The fluctuations in all variables were calculated with the data filtered with a high-pass recursive filter prior to the eddy correlation calculations.

4. Equipment:

Sensor/Instrument Description:

Air motion relative to the aircraft is measured by a nose-mounted gust boom. Airspeed, altitude, angles of attack, and sideslip are sensed on the boom by a Rosemount 858 5-hole probe and associated pressure transducers. The inertial velocity of the aircraft is computed in aircraft axes using a complementary filtering technique with the high-frequency contribution from integrated accelerometer and rate gyro signals, and the low-frequency velocity from a three-axis Doppler radar. The three components of true air motion are then derived from the difference between the air velocity relative to the aircraft and the inertial velocity relative to the ground, and resolved into Earth-fixed axes using the aircraft heading and attitude signals. Fluctuations in water and CO2 are measured by a fast-response infrared gas analyzer installed within a duct in the rear cabin. The air intake is from a 120 square cm inlet on the top of the fuselage. Temperature and pressure are measured within the duct to compute flow velocity and allow for density corrections to the CO2 and water flux measurements (Webb et al., 1980). Data are time-adjusted to correct for the separation between the gust boom and the other sensors (MacPherson et al., 1987).

The instruments on the aircraft are listed in the table below.

Parameter Measured	**Instrument Type**	**Manufacturer & Model Number**	**Range#**	**Accuracy#**	**Resolution#**
Aircraft Position dependent)	Loran-C	ARNAV R-40-AVA-100	+/- 90 Lat +/-180 Lon	0.3 km (location	0.01 min
Inertial Ref. System (Strap-down INS)	Litton LTN-90-100	+/- 90 Lat +/-180 Lon	2.0 n mi per flt hr	0.01 min	
Inertial Velocity (3-axes)	Inertial Ref. System	Litton LTN-90-100	327 mps	2 mps	0.01 mps
Doppler Radar	Decca Model 72	256 mps x	0.5 mps	0.01 mps x	
64 mps z	.002 mps z				
Aircraft Heading	Gyro Compass	Sperry c-12	+/- 180 deg	+/- 2 deg	0.1 deg
Inertial Reference system	Litton LTN-90-100	+/- 180 deg	0.4 deg	0.01 deg	
Aircraft Attitudes	Gyro	Kearfott T2109	+/- 30 deg +/- 60 deg	0.3 deg	0.01 deg
Inertial Reference System	Litton LTN-90-100	+/- 180 deg	0.05 deg	0.01 deg	

Angular Rates	Rate Gyros	Smiths 402-RGA	+/- 20 roll +/- 10 others	0.05 [deg] [s^-1]	0.01 [deg] [s^-1]
Inertial Reference	Litton LTN-90-100	+/- 128 [deg][s^-1]	0.1 [deg] [s^-1]	0.01 [deg] [s^-1]	
Accel-erations	Accel-erometers	Systron-Donner 4211	+/- 0.6 g +/- 1.0 g	0.1 ms-2	0.01 [m] [s^-2]
Inertial Reference System	Litton LTN-90-100	+/- 4 g	0.01 g	0.01 [m] [s^-2]	
Total Temperature	Platinum Resistance, Heated	Rosemount 102DJ1CG	+/- 50 deg	0.5 deg	0.01 deg
Reverse Flow Total Temperature	Thermistor	NAE Built	+/- 50 deg	1.0 deg	0.01 deg
Surface Temperature	Infrared Radiometer	Barnes PRT-5	0-50 deg C	1.0 deg	0.01 deg
Dew Point Temperature	Hygrometer	EG & G Model 137 S10	+/- 50 deg	1.0 deg	0.01 deg
Total Temperature in Duct to Co2 Analyzer	Platinum Resistance, Unheated	Rosemount 102DJ1CG	0-50 deg C	0.5 deg	0.01 deg
Temperature in Static Pressure Transducer	Thermistor	ParoScientific	32-120 F	0.5 F	0.01 deg F
Static Pressure, Noseboom	Quartz Crystal Temperature Compensated	ParoScientific 215L-AW-012	300-1050 mb	0.5 mb	0.1 mb
Static Pressure, Fuselage	Variable Capacitance	Rosemount 1201F-1B4A1B	300-1050 mb	2 mb	0.1 mb
Static Pressure, Duct	Dual Diaphram Sensor	A.I.R AIR-DB-2C	0-1100 mb	1.0 mb	0.1 mb
Dynamic Pressure, Noseboom	Variable Capacitance	Rosemount 1221-1V7A1B	0-50 mb	0.2 mb	0.1 mb
Dynamic Pressure, Fuselage	Variable Capacitance	Rosemount 1221F-2VL7A1A	0-50 mb	0.2 mb	0.1 mb
Dynamic Pressure, Duct	Variable Capacitance	Rosemount 1221F-2VL7A1A	0-50 mb	0.2 mb	0.1 mb
Angle of Attack, Differential Pressure	Noseboon 5-hole Probe, Variable Capacitance Transducer	Rosemount 858, 1221-1F1VL5A1	+/- 35 mb	0.2 mb	0.01 deg (alpha)
Angle of Sideslip, Differential Pressure	Noseboom 5-hole Probe, Variable Capacitance Transducer	Rosemount 858, 1221-1F1VL5A1	+/- 35 mb	0.2 mb	0.01 deg (beta)
Noseboom 5-hole Probe, Variable Capacitance Transducer	Rosemount 858, 1221-1F1VL5A1	+/- 35 mb	0.2 mb	0.01 deg (beta)	
Geometric Altitude	Radio Altimeter	Sperry AA-200	0-762 m	1m to 30m 3% to 150m	0.1 m

4% > 150m					
Carbon Dioxide Concentration ential)	Infrared Absorption	Agriculture Canada, ESRI	0-700 [mg][m^-3]	0.5 [mg] [m^-3] (differ-	0.1 [mg] [m^-3]
Water Vapor Concentration	Infrared Absorption	Agriculture Canada, ESRI	0-30 [mg][m^-3]	0.05 [mg][m^-3]	0.01 [mg][m^-3]
Incident Radiation, Visible	Pyranometer	Kepp & Zonen CM-11	0-1100 [mg][m^-3]	15 [mg][m^-3]	1.0 [mg] [m^-3]
Reflected Radiation, Visible	Pyranometer	Eppley	0-1100 [mg][m^-3]	15 [mg] [m^-3]	1.0 [mg] [m^-3]
Vegetation Index at 660 and 730 nm	Reflected Radiation	Skye Industries SKR-100	0-2000 [mg][m^-3]	---	0.001 ratio
Weather Radar		Bendix RDR-1300			
Photography Cameras ahead, 45 deg down, Instrument Panel	--- WV-CD101	VHS Video	Panasonic	6 hours	

Quoted range and resolution as recorded on aircraft data acquisition system (recorded range is generally less than instrument capability). Accuracy is the combination of manufacturer's specifications and operational experience.

Collection Environment:

Airborne.

Source/Platform:

- Twin Otter DHC-6-200 twin turboprop utility transport aircraft.
- Maximum gross takeoff weight 11579 lb.
- Service ceiling 20,000 ft.
- Endurance 3 to 4 hours, depending on instrumentation and weather.

Source/Platform Mission Objectives:

The Twin Otter atmospheric research aircraft is a highly instrumented platform for research on the atmospheric boundary layer, air pollution, etc.

Key Variables:

Fluxes of latent heat, CO2, water vapor concentration, and momentum.

Principles of Operation:

As the aircraft flies through the air, instruments on the nose boom and other outer surfaces of the aircraft make direct measurements. Some measurements (gas analysis) are made by instruments located inside the aircraft by having air drawn through them from large ducts in the rear fuselage. See the *Theory of Measurements Section* and MacPherson et al., (1981) for details.

Sensor/Instrument Measurement Geometry:

See MacPherson (1988, 1990a, 1990b).

Manufacturer of Sensor/Instrument:

See the *Sensor/Instrument Description Section*.

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.

Specifications:

See the *Sensor/Instrument Description Section*.

Tolerance:

See the *Sensor/Instrument Description Section*.

Frequency of Calibration:

All instruments were calibrated at least once per IFC.

Other Calibration Information:

None provided at this revision.

5. Data Acquisition Methods:

Most of the flux-measurement missions over FIFE during IFC-3 and IFC-4 involved coordinated patterns with the Wyoming King Air and the Twin Otter. One such flight included a horizontal grid pattern for the Twin Otter and a vertical "stack" of horizontal passes for the King Air. The "stack" in this case included W-to-E then E-to-W passes at each of four different levels (1010, 730, 580, and 520 m MSL), followed by a repeat of the same pattern. There were several other types of flight profile.

64 channels of data are recorded digitally in 64-bit words at 16 samples per second on a Control Data Model 92192 Streamer Tape Drive. Most signals are low-pass filtered with a breakpoint of 5 Hz to prevent aliasing.

6. Observations:

Data Notes:

Not available.

Field Notes:

NOTE 1:

Calculation of wind components is described in reports referenced in the *Satellite/Instrument/Data Processing Documentation*. The air velocity relative to the aircraft is measured by the 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 micro-processor. 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:

For IFC-4 and all 1989 FIFE flights, a second inertial velocity measuring system was interfaced to the computer and recording system. This was a Litton 90 inertial reference system, which is similar to an INS, but measures the velocities, accelerations, and rates in aircraft axes as well as Earth axes. For FIFE 1989, this was also used to derive a second and third set of wind calculations (channels 11, 13, 15, 19, 20, 21,42, 43, and 44 above).

***** IMPORTANT ****:**

In 1987 (IFC 2 and 3), the winds used for the flux calculations were those derived by the complementary-filtered Doppler/inertial system (channels 16,17, and 18 above). With the exception of flight 01 in 1989 and flight 36 in IFC-4, IFC-4 and IFC-5 (1989) data were derived using the Litton-90 for the inertial velocity (channels 19, 20, and 21 above).

***** VERY IMPORTANT ****:**

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 reference 5. These studies reveal that fluxes derived with the older Doppler-based system appear to be underestimated by 10-15 percent. Therefore, it is likely that archived fluxes are under-estimated for IFC-2 and IFC-3, flight 36 in IFC-4, and flight 89-01 in IFC-5.

NOTE 3:

A third-order high-pass filter was used to remove trends in these data prior to calculation of the high-pass filtered fluxes. At an average Twin Otter speed of 60 mps, this represents a long wavelength cut-off of 5 km, or about 1/3 the length of the average run.

NOTE 4:

*** The latest archive has three sets of fluxes, using (1) raw, (2) linearly detrended, and (3) high-pass filtered data. The archive has been divided up into three separate data sets (i.e., raw, detrended, and filtered).

NOTE 5:

References 3 and 6 give a description of a routine used to correct the radup reading for aircraft attitude changes. References 3 and 5 will give all the flight tracks for the 58 flights, and figures showing the way points used for flying the tracks mentioned below.

See note A below regarding numbering of runs in the data set.***

Note A:

The following convention applies to the numbering of runs: those labeled "REG NN" (where NN is a number) are segments of the regional run between Salina and the FIFE project area. This run is 79 kilometers in length. The 1989 track was different track than that flown in 1987. The east end of this run was near the eastern edge of the FIFE area just south of I-70.

The end points for this run are:

- West Latitude: 38 42.0 Longitude: 97 13.4
- East Latitude: 39 02.8 Longitude: 96 26.3

The above way points were used on all regional runs from 1989 flights 2-16. For flight 01 only, the end points of the regional run were:

- West Latitude: 38 49.0 Longitude: 97 16.0
- East Latitude: 39 03.3 Longitude: 97 26.3

Each regional run was divided into two segments to compare fluxes over the prairie grasses (East half) with those over mostly farmland (West half).

In 1987, the regional run used had the following end points:

    - West Latitude: 38 44.0 Longitude: 97 26.0
    - East Latitude: 38 56.4 Longitude: 96 35.0

- Those labeled "RUN NN" (where NN is a number) are runs over the FIFE study area (grids, L-patterns, T-patterns).
- Those labeled "INT NN" are comparisons with the other flux aircraft; those comparisons that were flown as part of a regular pattern over the FIFE study area will have the "RUN NN" or "REG NN" designation.
- Those labeled "LID NN" are special comparison runs with lidar.

7. Data Description:

Spatial Characteristics:

The FIFE study area, with areal extent of 15 km by 15 km, is located south of the Tuttle Reservoir and Kansas River, and about 10 km from Manhattan, Kansas, USA. The northwest corner of the area has UTM coordinates of 4,334,000 Northing and 705,000 Easting in UTM Zone 14.

Spatial Coverage:

Grid flight patterns consisted of twin sets of eight E-W trajectories of 15 km length, separated by 1.85 km in the N-S direction, flown in such a sequence that, on the average, every gridline was sampled at the same absolute time. Although this was only one of several flight patterns flown, it gave the broadest spatial coverage of the FIFE project area. To examine long-wavelength boundary layer processes and the results on the fluxes, data were also recorded on 75 km regional runs from the Salina area to the FIFE project area.

Spatial Coverage Map:

Not available.

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) and the anti-alias filtering applied to these data prior to recording (5.5 Hz). This translates to a basic sampling resolution of approximately 10 m.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

These data were collected during FIFE's five IFCs. Data were submitted to FIS staff for the following dates:

IFC#	Dates
IFC-1	June 6, 1987
IFC-2	June 26 to August 11, 1987
IFC-3	August 13 to August 20, 1987
IFC-4	October 6 to October 16, 1987
IFC-5	July 27 to August 12, 1989

Temporal Coverage Map:

Not available.

Temporal Resolution:

The aircraft data were recorded at a basic rate of 16 Hz. Flight duration was typically 3 to 3.5 hours. On several occasions there were two flights per day.

Data Characteristics:

The SQL definition for this table is found in the AF_FILTR.TDF file located on FIFE CD-ROM Volume 1.

Parameter/Variable Name			
Parameter/Variable Description	**Range**	**Units**	**Source**
OBS_DATE The date the observation was made on, in the format (DD-MMM-YY).			
START_TIME The starting time for the observation run in GMT, in the format (HHMM). The seconds for this time is stored in START_SECONDS.		[GMT]	

START_SECONDS The seconds component of the START_TIME (format SS).	[GMT]
DURATION The duration of the flight in the format (MMSS).	
AIRCRAFT_ID The ID name for the aircraft which made the observation run.	
START_LAT The starting latitude for the observation run.	
START_LON The starting longitude for the observation run.	
START_NORTHING The starting northing position of the aircraft in UTM coordinates.	[meters]
START_EASTING The starting easting position of the aircraft in UTM coordinates.	[meters]
END_LAT The ending latitude for the observation run.	
END_LON The ending longitude for the observation run.	
END_NORTHING The ending northing position of the aircraft in UTM coordinates.	[meters]
END_EASTING The ending easting position of the aircraft in UTM coordinates.	[meters]

HEADING The heading of the aircraft. from North]	[degrees
HEIGHT_ABOVE_MEAN_SEA_LVL The altitude of the aircraft above mean sea level, as determined by air pressure.	[meters]
HEIGHT_ABOVE_GRND_LVL The altitude of the aircraft above the ground, as determined by radar.	[meters]
AIR_TEMP_MEAN The mean air temperature. Celsius]	[degrees
POTNTL_TEMP_MEAN The potential mean air temperature. Kelvin]	[degrees
MIX_RATIO_MEAN The mixing ratio taken from a dew-point hygrometer.	[grams] [kg^-1]
NS_WIND_VELOC_MEAN The mean north/south wind component (V), with north being positive.	[meters] [sec^-1]
EW_WIND_VELOC_MEAN The mean east/west wind component (U), with east being positive.	[meters] [sec^-1]
PRESS_MEAN The mean air pressure.	[millibars]
SURF_TEMP_MEAN The mean surface temperature. Celsius]	[degrees
DOWNWELL_RADTN_MEAN The mean downwelling radiation count.	[Watts] [meter^-2]

UPWELL_RADTN_MEAN
The mean upwelling radiation count. [Watts] [meter^-2]

VEG_INDEX_MEAN
The mean vegetation (greenness) index.

AIR_TEMP_RMS
The root mean square of the temperature recorded in column AIR_TEMP_MEAN. [degrees Celsius]

POTNTL_TEMP_RMS
The root mean square of the potential temperature recorded in the column POTNTL_TEMP_MEAN. [degrees Kelvin]

MIX_RATIO_RMS
The root mean square of the mixing ratio recorded in the column MIX_RATIO_MEAN, taken from a dew-point hygrometer. [grams] [kg^-1]

NS_WIND_VELOC_RMS
The root mean square of the north/south wind component recorded in column NS_WIND_VELOC_MEAN. [meters] [sec^-1]

EW_WIND_VELOC_RMS
The root mean square of the east/west wind component recorded in column EW_WIND_VELOC_MEAN. [meters] [sec^-1]

PRESS_RMS
The root mean square of the pressure recorded in column PRESS_MEAN. [millibars]

SURF_TEMP_RMS
The root mean square of the surface temperature recorded in column SURF_TEMP_MEAN. [degrees Celsius]

DOWNWELL_RADTN_RMS
The root mean square of the downwelling radiation count [Watts] [meter^-2]

recorded in column DOWNWELL_RADTN_MEAN.	
UPWELL_RADTN_RMS The root mean square of the upwelling radiation recorded in column UPWELL_RADTN_MEAN.	[Watts] [meter^-2]
VEG_INDEX_RMS The root mean square of the vegetation (greenness) index recorded in column VEG_INDEX_MEAN.	
AIR_TEMP_LINEAR The linear trend of the temperature recorded in the column AIR_TEMP_MEAN.	[degrees Celsius] [meter^-1]
POTNTL_TEMP_LINEAR The linear trend of the potential temperature recorded in column POTNTL_TEMP_MEAN.	[degrees Kelvin] [meter^-1]
MIX_RATIO_LINEAR The linear trend of the mixing ratio recorded in column MIX_RATIO_MEAN (derived from dew point).	[grams] [kg^-1] [meter^-1]
NS_WIND_VELOC_LINEAR The linear trend of the north/south wind component recorded in column NS_WIND_VELOC_MEAN.	[meters] [sec^-1] [meter^-1]
EW_WIND_VELOC_LINEAR The linear trend of the east/west wind component recorded in column EW_WIND_VELOC_MEAN.	[meters] [sec^-1] [meter^-1]
PRESS_LINEAR The linear trend of the pressure recorded in column PRESS_MEAN.	[millibars] [meter^-1
SURF_TEMP_LINEAR The linear trend of the surface temperature recorded in column SURF_TEMP_MEAN.	[degrees Celsius][me [meter^-1]

DOWNWELL_RADTN_LINEAR The linear trend of the downwelling radiation count recorded in DOWNWELL_RADTN_MEAN.	[Watts] [meter^-2] [meter^-1]
UPWELL_RADTN_LINEAR The linear trend of the upwelling radiation count recorded in column UPWELL_RADTN_MEAN.	[Watts] [meter^-2] [meter^-1]
VEG_INDEX_LINEAR The linear trend of the vegetation (greenness) index recorded in column VEG_INDEX_MEAN.	
MOIST_AIR_DENSITY_X_CP The moist air density times specific heat capacity (CP). Kelvin^-1	[Watts][sec] [degrees
LATENT_HEAT_OF_VAPOR The latent heat of vaporization at 20 degrees Celsius. [gram^-1]	[Watts] [sec]
MOIST_AIR_DENSITY The moist air density. [meter^-3]	[kg]
VERT_GUST_VELOC_RMS_FLTR The root mean square of the vertical wind gust velocity.	[meters] [sec^-1]
NS_GUST_VELOC_RMS_FLTR The root mean square of the north/south wind (U) gust velocity.	[meters] [sec^-1]
EW_GUST_VELOC_RMS_FLTR The root mean square of the east/west wind (V) gust velocity.	[meters] [sec^-1]
ALONG_WIND_VELOC_RMS_FLTR The root mean square of the along-wind component of the wind gust velocity.	[meters] [sec^-1]

ACROSS_WIND_VELOC_RMS_FLTR The root mean square of the across-wind component of the wind gust velocity.	[meters] [sec^-1]
POTNTL_TEMP_RMS_FLTR The root mean square of the potential temperature.	[degrees Kelvin]
WATER_MIX_RATIO_RMS_FLTR The root mean square of the water mixing ratio (lyman alpha).	[grams] [kg^-1]
CO2_MIX_RATIO_RMS_FLTR The root mean square of the carbon dioxide content.	[milligrams] [kg^-1]
VERT_GUST_VELOC_SKEW_FLTR The skewness of the vertical gust wind velocity.	
NS_GUST_VELOC_SKEW_FLTR The skewness of the north/south wind gust velocity.	
EW_GUST_VELOC_SKEW_FLTR The skewness of the east/west wind gust velocity.	
ALONG_WIND_VELOC_SKEW_FLTR The skewness of the along-wind component of the wind gust velocity.	
ACROSS_WIND_VELOC_SKEW_FLTR The skewness of the across-wind component of the wind gust velocity.	
POTNTL_TEMP_SKEW_FLTR The skewness of the potential temperature.	
WATER_MIX_RATIO_SKEW_FLTR The skewness of the water mixing ratio.	

CO2_MIX_RATIO_SKEW_FLTR The skewness of the carbon dioxide content.	
NS_MOMNTM_FLUX_FLTR The north/south momentum flux, calculated from W*V (wind components).	[Newtons] [meter^-2]
EW_MOMNTM_FLUX_FLTR The east/west momentum flux, calculated from W*U (wind components).	[Newtons] [meter^-2]
ALONG_MOMNTM_FLUX_FLTR The along-wind momentum flux, calculated from W*along-wind gust (wind components).	[Newtons] [meter^-2]
ACROSS_MOMNTM_FLUX_FLTR The across-wind momentum flux, calculated from W*across-wind gust	[Newtons] [meter^-2]
SENSIBLE_HEAT_FLUX_FLTR The sensible heat flux. [meter^-2]	[Watts]
LATENT_HEAT_FLUX_FLTR The latent heat flux. [meter^-2]	[Watts]
CO2_FLUX_FLTR The carbon dioxide flux. [hectare^-1] [hour^-1]	[kg]
NS_MOMNTM_CC_FLTR The correlation coefficient for vertical wind velocity and north/south wind gusts.	
EW_MOMNTM_CC_FLTR The correlation coefficient for vertical wind velocity and east/west wind gusts.	

ALONG_MOMNTM_CC_FLTR
The correlation coefficient for vertical wind velocity and along-wind component of the wind gust velocity.

ACROSS_MOMNTM_CC_FLTR
The correlation coefficient for vertical wind velocity and across-wind component of the wind gust velocity.

SENSIBLE_HEAT_CC_FLTR
The correlation coefficient for the sensible heat flux.

LATENT_HEAT_CC_FLTR
The correlation coefficient for the latent heat flux.

CO2_FLUX_CC_FLTR
The correlation coefficient for the CO2 flux.

MIX_RATIO_CC_FLTR
The correlation coefficient for the mixing ratio * potential temperature.

COMMENTS
Any comments pertaining to this record.

FIFE_DATA_CRTFCN_CODE
The FIFE Certification Code for the data, in the following format: CPI (Certified by PI), CPI-??? (CPI - questionable data). **

LAST_REVISION_DATE
data, in the format (DD-mmm-YY).

Footnote:

The missing value for most of the numerical fields is 99.999.

** Valid levels

The primary certification codes are: EXM Example or Test data (not for release). PRE Preliminary (unchecked, use at your own risk). CPI Checked by Principal Investigator (reviewed for quality). CGR Checked by a group and reconciled (data comparisons and cross-checks).

The certification code modifiers are: PRE-NFP Preliminary - Not for publication, at the request of investigator. CPI-MRG PAMS data that are "merged" from two separate receiving stations to eliminate transmission errors. CPI-??? Investigator thinks data item may be questionable.

Sample Data Record:

OBS_DATE	START_TIME	START_SECONDS	DURATION	AIRCRAFT_ID	START_LAT
04-AUG-89	1443	0	411	NAE	3859.8
04-AUG-89	1458	22	427	NAE	3859.6
04-AUG-89	1504	35	528	NAE	3900.5
04-AUG-89	1511	36	424	NAE	3901.7

START_LON	START_NORTHING	START_EASTING	END_LAT	END_LON	END_NORTHING
-9637.2			3859.5	-9626.4	
-9637			3859.6	-9626.3	
-9626			3900.6	-9637	
-9637			3901.6	-9626.2	

END_EASTING	HEADING	HEIGHT_ABOVE_MEAN_SEA_LVL	HEIGHT_ABOVE_GRND_LVL
99	778	375	
97	504	87	
263	504	90	
96	505	100	

AIR_TEMP_MEAN	POTNTL_TEMP_MEAN	MIX_RATIO_MEAN	NS_WIND_VELOC_MEAN
23.75	304.21	14.38	5.26
26.61	304.26	14.88	6.02
26.69	304.34	14.89	6.89
26.77	304.44	14.93	5.82

EW_WIND_VELOC_MEAN	PRESS_MEAN	SURF_TEMP_MEAN	DOWNWELL_RADTN_MEAN
7.52	918.4	27.5	513
4.68	949.2	29	544
4.53	949.3	29	571
4.5	949.1	29	578

UPWELL_RADTN_MEAN	VEG_INDEX_MEAN	AIR_TEMP_RMS	POTNTL_TEMP_RMS
88	2.09	.3	.29
94	2.27	.15	.14
97	2.33	.16	.15
103	2.46	.16	.16

MIX_RATIO_RMS	NS_WIND_VELOC_RMS	EW_WIND_VELOC_RMS	PRESS_RMS
.44	.81	1.26	.6
.4	.96	.91	.6
.4	1.05	.82	.6
.4	1.01	.99	.6

SURF_TEMP_RMS	DOWNWELL_RADTN_RMS	UPWELL_RADTN_RMS	VEG_INDEX_RMS
1.3	6	5	.27
1.8	8	7	.47
2.2	7	6	.4

2.1	8	10	.43

AIR_TEMP_LINEAR	POTNTL_TEMP_LINEAR	MIX_RATIO_LINEAR
-.0000254	-.0000235	.0000305
.00000148	-.00000194	.0000135
-.0000057	-.00000293	-.0000119
.0000235	.0000235	.00000219

NS_WIND_VELOC_LINEAR	EW_WIND_VELOC_LINEAR	PRESS_LINEAR
-.0000634	-.000139	-.000026
-.0000491	-.0000341	.0000375
.0000134	.0000169	-.0000312
.0000913	.00000852	.00000467

SURF_TEMP_LINEAR	DOWNWELL_RADTN_LINEAR	UPWELL_RADTN_LINEAR
-.0000452	.000759	.000922
-.000154	.000785	.000935
.00019	.000791	-.000894
-.000164	.000963	.00136

VEG_INDEX_LINEAR	MOIST_AIR_DENSITY_X_CP	LATENT_HEAT_OF_VAPOR
.0000506	1083.1	2591.9
.0000695	1108.7	2642.2
-.0000542	1108.5	2641.4
.0000424	1108	2639.4

MOIST_AIR_DENSITY	VERT_GUST_VELOC_RMS_FLTR	NS_GUST_VELOC_RMS_FLTR
1.078	.48	.69
1.103	.79	.81
1.103	.72	.9
1.102	.7	.87

EW_GUST_VELOC_RMS_FLTR	ALONG_WIND_VELOC_RMS_FLTR
.9	.8
.84	.85
.76	.86
.9	.9

ACROSS_WIND_VELOC_RMS_FLTR	POTNTL_TEMP_RMS_FLTR	WATER_MIX_RATIO_RMS_FLTR
.8	.19	.21
.79	.12	.15
.8	.1	.14
.87	.1	.16

CO2_MIX_RATIO_RMS_FLTR	VERT_GUST_VELOC_SKEW_FLTR	NS_GUST_VELOC_SKEW_FLTR
.75	99.999	99.999
1.09	99.999	99.999
1.01	99.999	99.999
1.2	99.999	99.999

EW_GUST_VELOC_SKEW_FLTR	ALONG_WIND_VELOC_SKEW_FLTR
99.999	99.999
99.999	99.999
99.999	99.999
99.999	99.999

ACROSS_WIND_VELOC_SKEW_FL	POTNTL_TEMP_SKEW_FLTR
99.999	99.999
99.999	99.999
99.999	99.999
99.999	99.999

WATER_MIX_RATIO_SKEW_FLTR	CO2_MIX_RATIO_SKEW_FLTR	NS_MOMNTM_FLUX_FLTR

99.999	99.999	-.01
99.999	99.999	-.2
99.999	99.999	-.19
99.999	99.999	-.18

EW_MOMNTM_FLUX_FLTR	ALONG_MOMNTM_FLUX_FLTR	ACROSS_MOMNTM_FLUX_FLTR
-.12	-.1	.06
-.3	-.34	.11
-.18	-.26	.04
-.19	-.26	.04

SENSIBLE_HEAT_FLUX_FLTR	LATENT_HEAT_FLUX_FLTR	CO2_FLUX_FLTR
-18	53	.5
65	201	-19.9
39	142	-12.4
33	151	-16.2

NS_MOMNTM_CC_FLTR	EW_MOMNTM_CC_FLTR	ALONG_MOMNTM_CC_FLTR
-.03	-.25	-.24
-.29	-.41	-.46
-.26	-.29	-.37
-.27	-.27	-.37

ACROSS_MOMNTM_CC_FLTR	SENSIBLE_HEAT_CC_FLTR	LATENT_HEAT_CC_FLTR
.14	-.18	.2
.16	.61	.63
.07	.47	.52
.05	.42	.52

CO2_FLUX_CC_FLTR	MIX_RATIO_CC_FLTR	COMMENTS
.03	-.83	
-.59	.83	
-.43	.77	
-.5	.64	

FIFE_DATA_CRTFCN_CODE	LAST_REVISION_DATE
CPI	24-AUG-92
CPI	24-AUG-92
CPI	24-AUG-92
CPI	24-AUG-92

8. Data Organization:

Data Granularity:

The data set grid flight patterns consisted of twin sets of eight E-W trajectories of 15 km length, separated by 1.85 km in the N-S direction, flown in such a sequence that, on the average, every gridline was sampled at the same absolute time. The basic sampling resolution was approximately 10 m. The aircraft data were recorded at a basic rate of 16 Hz. Flight duration was typically 3 to 3.5 hours. On several occasions there were two flights per day.

A general description of data granularity as it applies to the IMS appears in the EOSDIS Glossary.

Data Format:

The CD-ROM file format consists of numerical and character fields of varying length separated by commas. The character fields are enclosed with a single apostrophe. There are no spaces between the fields. Each file begins with five header records. Header records contain the following information: Record 1 Name of this file, its table name, number of records in this file, path and name of the document that describes the data in this file, and name of principal investigator for these data. Record 2 Path and filename of the previous data set, and path and filename of the next data set. (Path and filenames for files that contain another set of data taken at the same site on the same day.) Record 3 Path and filename of the previous site, and path and filename of the next site. (Path and filenames for files of the same data set taken on the same day for the previous and next sites (sequentially numbered by SITEGRID_ID)). Record 4 Path and filename of the previous date, and path and filename of the next date. (Path and filenames for files of the same data set taken at the same site for the previous and next date.) Record 5 Column names for the data within the file, delimited by commas. Record 6 Data records begin.

Each field represents one of the attributes listed in the chart in the *Data Characteristics Section* and described in detail in the TDF file. These fields are in the same order as in the chart.

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

1. Calculation of wind components is described in MacPherson et al., (1981).

   The air velocity relative to the aircraft is measured by the TAS and noseboom angles of attack and sideslip. The Aircraft inertial velocity relative to the earth is measured in aircraft axes by a system incorporating complementary filtering in real time on the aircraft microprocessor. A system of accelerometers and rate gyros provides the high-frequency components to this filter, the Decca 3-Axis Doppler Radar provides the low-frequency components. The resulting calculated velocity components in A/C axes are subtracted from the TAS components to get the three components of wind in A/C axes. These are then resolved into Earth axes using the pitch and roll attitude and the aircraft heading.

2. For IFC-4 and 5, a second inertial velocity measuring system was interfaced to the computer and recording system. This was a Litton 90 Inertial Reference System. This is similar to an INS, but measures the velocities, accelerations and rates in aircraft axes as well as Earth axes. This was used to derive a second set of wind calculations (channels 11, 13, 15, 19, 20, and 21 above).
3. For each flight, the ground speed for all runs was averaged. The HP filtered breakpoint was then selected as the average ground speed divided by 5000 m. This gave a breakpoint of about 0.012 Hz.
4. Three sets of fluxes were derived, one using 'raw' data, one using linearly detrended time histories, and one using high-pass filtered data. This data set contains the filtered data, as

well as correlation coefficients and rms values of parameters contributing to the flux estimates. Details of the wind and flux calculations can be found in MacPherson (1990b)

Data Processing Sequence:

Processing Steps:

Data collected by instruments aboard the Twin Otter are processed in real time by two microprocessors carried onboard the aircraft. An LSI-11/73 performs computations of wind, approximate fluxes, etc., and a DEC Falcon manages the recording of the sensor outputs and the computed parameters. The two are connected by a Communications Interface Board. Full inflight interaction with the main processor via a console-mounted keyboard takes place in the cockpit, with programs loaded from a dual floppy disk unit.

Fluxes were calculated using the procedures detailed in MacPherson (1990b). It should be noted that in the final submission to the FIS, three sets of flux and 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, the third used time histories that were high-pass filtered with a third-order algorithm with a breakpoint set at 0.012 Hz (5 km wavelength). It is felt that most scientists working with the flux and correlation coefficient data, would prefer to use the linearly detrended data. Data from the NCAR and University of Wyoming King Air aircraft were archived with identical formats.

Processing Changes:

There was a change in the method used to derive the wind components after IFC 3. This is described fully in MacPherson (1990a). Also see Notes 1 and 2 in the *Field Notes Section* above, and the *Special Corrections/Adjustments Section* below.

Calculations:

Special Corrections/Adjustments:

None.

Calculated Variables:

Not available.

Graphs and Plots:

MacPherson (1988, 1990a) gives flight track plots for each flight, plotted tephigrams, and wind hodographs for each profile sounding flown. There are various other plots of processed data..

10. Errors:

Sources of Error:

Instrument Status:

1. The LICOR CO2 analyzer was not used during IFC-2, IFC-3, and IFC-4.
2. The Litton-90 inertial reference system, used for measuring the ground-referenced wind velocity, was unavailable for IFC-2 and IFC-3. In IFC-2 and IFC-3, winds were derived using ground-referenced velocities determined from a complementary filtering technique that used data from 3-axis Doppler radar, accelerometers and rate Gyros. This system continued to be used as the back-up system in 1989, and data from both sets of wind computations were recorded.
3. On July 11/87, the atmospheric pollution caused the mirrors on the CO2/H2O Analyzer to gradually become dirty. This caused a drift in both the CO2 and H2O readings. This should not affect the fluxes, which use high-pass filtered data.
4. On the first flight of October 11/87 (NA871011.A), a computer problem occurred on runs 11 to 16 inclusive. These runs have not been included in this data set.
5. On the first flight of July 11/87 (NA870711.A), the filtered C02 signal is U/S for run 17.

Note that in IFC 2 and 3, the Doppler-based winds were used, which likely cause an underestimation of the fluxes by 10-15 percent (see important note near top of this document, refer to references as well) this underestimation will likely apply to data archived for flt 36 in IFC 4, and flight 01 in IFC 5

NOTE 10:

On several flights in IFC 2, 3, there was an instrumentation problem that caused spikes or dropouts on the following signals: - pitch and roll attitude (channels 57, 58 on original tape-see above) - heading (channel 10).

Because these signals are used in deriving the wind components UGE (ch 16), VGE (ch 17), and WGE (ch 18) and wind direction (12) and wind speed (14), spikes can result in the derived winds. These will have a small effect on the run averages archived. The spikes on WGE and the vertical gust component can have a significant effect on the fluxes, however. Therefore, for the flights indicated below with "WGAI used, see note 10", the uncontaminated WGAI (channel 54), the vertical gust in airplane axes, is used in the flux calculations. For level flight, WGAI and WGE are almost identical.

Because the heading and attitudes are used to correct the upward radiometer signal (ch 26), no corrections were done for aircraft attitude changes for flights with spikes in the attitude/heading data in IFC-2. In IFC-3, flts 15-19, the radiation signal was corrected using the attitudes with spikes, thus the radiation values may be in error several percent.

NOTE 11:

The same spike problem discussed in *Note 10* sometimes affected noseboom static pressure (ch 35), which in turn affects TASNB (ch 32), the noseboom true airspeed used in the wind calculations. When this occurred, the alternative fuselage static pressure (PSF, ch. 49) and TASF (ch. 31) were used. These cases are denoted by "PSF and TASF used-see note 11".

NOTE 12:

In using the Twin Otter recorded position data, two sources of error must be taken into account. First, there was a fairly consistent offset in the Loran position compared to the true position, probably due to the location of the FIFE site relative to the Loran transmitting stations. It would appear that the Loran-C recorded a position about 0.8 km northeast of the actual position.

In order to fly the correct ground tracks, all the way point data entered into the Loran-C system were adjusted to account for this offset. This in effect moved the Earth into the Loran-C reference frame. It does not mean that the recorded positions are correct-the aircraft is approx. 0.8 km southwest of the recorded position.

The positions of the tracks flown for each run are given in MacPherson (1988, 1989). Because the Loran way points were adjusted for the offset, the actual tracks flown are very close to those planned, as given in MacPherson (1988, 1989).

A second source of error is a lag within the Loran-C. The calculated (and recorded) position appears to lag the correct position by about 4 seconds (approximately 0.25 km) at Twin Otter speeds.

Quality Assessment:

Data Validation by Source:

Great care has been taken in the collection and analysis of the Twin Otter FIFE data. The wind measuring system is continually monitored for accuracy using techniques such as wind boxes, control input cases, and inter-comparisons with other aircraft (see Reference 7). 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.

Confidence Level/Accuracy Judgment:

The Principal Investigator is confident that these data are of high quality barring the errors mentioned in the *Sources of Error Section*.

Measurement Error for Parameters:

See the *Sensor/Instrument Description Section*.

Additional Quality Assessments:

FIS staff applied a general Quality Assessment (QA) procedure to these data to identify inconsistencies and problems for potential users. As a general procedure, the FIS QA consisted of examining the maximum, minimum, average, and standard deviation for each numerical field in the data table. An attempt was made to find an explanation for unexpected high or low values, values outside of the normal physical range for a variable, or standard deviations that appeared inconsistent with the mean. In some cases, histograms were examined to determine whether outliers were consistent with the shape of the data distribution.

The discrepancies, which were identified, are reported as problems in the *Known Problems with the Data Section*.

Data Verification by Data Center:

The data verification performed by the ORNL DAAC deals with the quality of the data format, media, and readability. The ORNL DAAC does not make an assessment of the quality of the data itself except during the course of performing other QA procedures as described below.

The FIFE data were transferred to the ORNL DAAC via CD-ROM. These CD-ROMs are distributed by the ORNL DAAC unmodified as a set or in individual volumes, as requested. In addition, the DAAC has incorporated each of the 98 FIFE tabular data sets from the CD-ROMs into its online data holdings. Incorporation of these data involved the following steps:

- copying the entire FIFE Volume 1, maintaining the directory structure on the CD-ROM.
- using data files, documentation, and SQL code provided on the CD-ROM to create a database in Statistical Analysis System (SAS).
- creating transfer files to transfer the SAS metadata database to Sybase tables.

Each distinct type of data (i.e. "data set" on the CD-ROM), is accompanied by a documentation file (i.e., .doc file) and a data format/structure definition file (i.e., .tdf file). The data format files on the CD-ROM are Oracle SQL commands (e.g., "create table") that can be used to set up a relational database table structure. This file provides column/variable names, character/numeric type, length, and format, and labels/comments. These SQL commands were converted to SAS code and were used to create SAS data sets and subsequently to input data files directly from the CD-ROM into a SAS data set. During this process, file names and directory paths were captured and metadata was extracted to the extent possible electronically. No files were found to be corrupted or unreadable during the conversion process.

Additional Quality Assurance procedures were performed as follows:

- Statistical operations were performed to calculate minimum and maximum values for all numeric fields and to create a listing of all values of the character fields. During this process, it was determined that various conventions were used to represent missing values. (Note: no modifications were made to any data by the DAAC). In most cases, missing value identification conventions were discussed in the accompanying .doc file. Based on a visual check of the minimum and maximum values, no glaring errors or holes were identified that might indicate errors introduced during CD-ROM mastering by the FIFE project or data ingest by the DAAC.

- Some minor inconsistencies and typographical errors were identified in some of the character fields and column labels, however, no modifications were made to the data by the DAAC.
- Some conversions of ASCII data were necessary to move the data from a DOS platform to a UNIX platform. Standard operating system conversion utilities were used (e.g., dos2unix).
- Much of the metadata required for archival is imbedded in the narrative documentation accompanying the data sets and extracted manually by DAAC staff who have read the .doc files provided on the CD-ROM and have hand entered this information into the metadata database maintained by the DAAC. QA procedures have been performed on these metadata to identify and eliminate typographical errors and inconsistencies in naming conventions, to ensure that all required metadata is present, and to ensure the accuracy of file names and paths for retrieval.
- Data requested for distribution to users are checked to verify that files copied from disk to other media remain uncorrupted.

As errors are discovered in the online tabular data by investigators, users, or DAAC staff, corrections are made in cooperation with the principal investigators. These corrections are then distributed to users. CD-ROM data are corrected when re-mastering occurs for replenishment of CD-ROM stock.

11. Notes:

Limitations of the Data:

Not available.

Known Problems with the Data:

The following potential problem was noted in the FIS staff QA check:

- The Latent_Heat_Flux on June 1, 1987 was found to have 7 values that were greater than 400. These points were much higher than the other values for this variable. They should be used with caution.

THE TABLE BELOW DOCUMENTS INSTRUMENTATION PROBLEMS THAT MAY AFFECT THE QUALITY OF DATA ARCHIVED.

```
      FLT   DATE    ARCHIVE FILE           INSTRUMENTATION PROBLEMS
**NOTE 12 applies to all flights**
_______________________________________________________________________
1987
01    JUN 26   NA870626.A       - Greenness index u/s (unserviceable)
this flight
02    JUN 26   NA870626.B       - PSF and TASF used--see NOTE 11
- WGAI used in fluxes--see NOTE 10
- Upward radiometer uncorrected for
```

aircraft attitude changes
- Greenness index u/s on first minute of
run 01
- Noise buzz on CO2 signal, part of run
10
03   JUN 28   NA870628.A   - PSF and TASF used--see NOTE 11
- WGAI used in fluxes--see NOTE 10
- Upward radiometer uncorrected for
aircraft attitude changes
04   JUN 28   NA870628.B   - PSF and TASF used--see NOTE 11
- WGAI used in fluxes--see NOTE 10
- Upward radiometer uncorrected for
aircraft attitude changes
05   JUL 09   NA870709.A   - H20 analyzer signal u/s until 16:24
GMT.
No water vapor fluxes for run 01-03
and lidar inter-comparison runs l-1 to
l-5
06   JUL 10   NA870710.A   - H20 analyzer signal u/s until 15:24
GMT.
No water vapor fluxes for runs 01-06
07   JUL 11   NA870711.A   - CO2 analyzer signal u/s for run 17
08   AUG 07   NA870807.B   - PSF and TASF used--see NOTE 11
- WGAI used in fluxes--see NOTE 10
- Upward radiometer corrected with noisy
attitude signals
09   AUG 09   NA870809.A   - Dew point inaccurate for 20 seconds in
reg 02- affects run average
- PSF and TASF used--see NOTE 11
- WGAI used in fluxes--see NOTE 10
- Upward radiometer corrected with noisy
attitude signals
10   AUG 09   NA870809.B   - PSF and TASF used--see NOTE 11
- WGAI used in fluxes--see NOTE 10
- Upward radiometer corrected with noisy
attitude signals
- Event marker left on into turn
following
run 05. Run 05 data therefore includes
this turn
11   AUG 11   NA870811.A   - PSF and TASF used--see NOTE 11
- WGAI used in fluxes--see NOTE 10
- Upward radiometer corrected with noisy
attitude signals
12   AUG 13   NA870813.A   - 256-bit dropouts on H20 signal.
Corrected by software on playback, but
there may be still some effect on H20
fluxes
13   AUG 14   NA870814.A   - CO2 signal u/s: no CO2 fluxes this
flight
14   AUG 17   NA870817.B   - Radio-altimeter intermittent after
21:32 GMT; affects regional runs
15   AUG 20   NA870820.A   - Radio-altimeter u/s
16   AUG 20   NA870820.B   - Radio-altimeter u/s
17   OCT 08   NA871008.A   - Litton 90 wouldn't align; used back-up
Doppler winds,
18   OCT 11   NA871011.A   - Processor problem 18:16-18:53 GMT. 6

```
runs omitted
1989
01    JUL 27   NA890727.A       - Litton horizontal winds not correct;
archive uses Doppler winds.
02    AUG 02   NA890802.A       - Haze may cause low greenness index
readings for runs at higher altitudes.
03    AUG 04   NA890804.A       - Run 02 aborted due to computer halt;
not archived, but repeated as run 03.
04    AUG 04   NA890804.B       - CO2 and fast response H20 unserviceable
during last run (reg 02); replaced by
9999 in archive file.
05    AUG 06   NA890806.A       - Run 09 lost due to computer halt.
06    AUG 06   NA890806.B       - Run 14 lost due to computer halt.
07    AUG 10   NA890810.A       - Computer problems after run 15; abort
remainder of flight.
08    AUG 10   NA890810.B       - This was a night flight; upward and
downward radiometers and greenness
index will not be usable.
- Not sure of what prt5 surface
temperature radiometer reads in the
dark, probably OK.
09    AUG 12   NA890812.A       - Greenness index unserviceable for runs
reg-02 and run-01.
```

Usage Guidance:

ALERT

Fluxes were calculated using the procedures detailed in MacPherson (1990b). It should be noted that in the final submission to the FIS, three sets of flux and 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, 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 the flux and correlation coefficient data, would prefer to use the linearly detrended data. Data from the NCAR and University of Wyoming King Air aircraft were archived with the identical formats.

Any Other Relevant Information about the Study:

None.

12. Application of the Data Set:

This data set can be utilized to relate boundary layer processes (e.g., 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 crop health and climate change

13. Future Modifications and Plans:

The FIFE field campaigns were held in 1987 and 1989 and there are no plans for new data collection. Field work continues near the FIFE site at the Long-Term Ecological Research (LTER) Network Konza research site (i.e., LTER continues to monitor the site). The FIFE investigators are continuing to analyze and model the data from the field campaigns to produce new data products.

14. Software:

Software to access the data set is available on the all volumes of the FIFE CD-ROM set. For a detailed description of the available software see the *Software Description Document*.

15. Data Access:

Contact Information:

ORNL DAAC User Services
Oak Ridge National Laboratory

Telephone: (865) 241-3952
FAX: (865) 574-4665

Email: ornldaac@ornl.gov

Data Center Identification:

ORNL Distributed Active Archive Center
Oak Ridge National Laboratory
USA

Telephone: (865) 241-3952
FAX: (865) 574-4665

Email: ornldaac@ornl.gov

Procedures for Obtaining Data:

Users may place requests by telephone, electronic mail, or FAX. Data is also available via the World Wide Web at http://daac.ornl.gov.

Data Center Status/Plans:

FIFE data are available from the ORNL DAAC. Please contact the ORNL DAAC User Services Office for the most current information about these data.

16. Output Products and Availability:

Filtered Boundary Layer Fluxes from the Twin Otter data are available on FIFE CD-ROM Volume 1. The CD-ROM filename is as follows:

\DATA\AIR_FLUX\AF_FILTR\NAE\YyyMmm\ydddMULT.NAF

Where *yy* is the last two digits of the year (e.g. Y87 = 1987) and *mm* is the month of the year (e.g. M12 = December). Note: capital letters indicate fixed values that appear on the CD-ROM exactly as shown here, lower case indicates characters (values) that change for each path and file.

The format used for the filenames is: *ydddMULT.sfx*, where *y* is the last digit of the year (e.g. 7 = 1987, and 9 = 1989), and *ddd* is the day of the year. The filename extension (.*sfx*), identifies the data set content for the file (see the *Data Characteristics Section*) and is equal to .NAF for the filtered data.

Videotapes from the undernose camera on the Twin Otter during all FIFE flights are available from the Principal Investigator, J. Ian MacPherson, (see the *Contact Information Section* for address information).

17. References:

Satellite/Instrument/Data Processing Documentation.

MacPherson, J.I., J.M. Morgan, and K. LLum. 1981. The NAE Twin Otter atmospheric research Aircraft. Lab. Tech. Rep. LTR-FR-80. National Research Council Canada. Ottawa, Ontario.

MacPherson, J.I., and S.W. Baillie. 1986. The NAE Atmospheric research aircraft. Misc. Report 62. National Research Council Canada. Ottawa, Ontario.

MacPherson, J.I. 1988. NAE Twin Otter operations in FIFE. Lab. Tech. Rep. LTR-FR-104. National Research Council Canada. Ottawa, Ontario.

MacPherson, J.I. 1989. NAE Twin Otter operations in the 1988 eulerian model evaluation field study. Lab. Tech. Rep. LTR-FR-107. National Research Council Canada. Ottawa, Ontario.

MacPherson, J.I. 1990a. NAE Twin Otter operations in FIFE 1989. Lab. Tech.Rep. LTR-FR-113. National Research Council Canada. Ottawa, Ontario.

MacPherson, J.I. 1990b. Wind and flux calculations on the NAE Twin Otter. Lab. Tech. Rep. LTR-FR-109. National Research Council Canada. Ottawa, Ontario.

Journal Articles and Study Reports.

Betts, A.K., R.L. Desjardins, J.I. MacPherson, and R.D. Kelly. 1990. Boundary layer heat and moisture budgets from FIFE. Boundary Layer Meteorol. 50:109-137.

Betts, A.K., R.L. Desjardins, and J.I. MacPherson. 1992. Budget analysis of the boundary layer grid flights during FIFE-87. J. Geophys. Res. 97:18,533-18,546.

Desjardins, R.L., P.H. Schuepp, J.I. MacPherrson, and D.J. Buckley. 1992. Spatial and temporal variations of carbon dioxide and sensible and latent heat fluxes over the FIFE site. J. Geophys. Res. 97:18,467-18,475.

Cihlar, J., P.H. Caramori, P.H. Schuepp, R.L. Desjardins, and J.I. MacPherson. 1992. Relationship between satellite-derived vegetation index and aircraft-based C02 measurements. J. Geophys. Res. 97:18,515-18,521.

Kelly, R.D., E.A. Smith, and J.I. MacPherson. 1992. A comparison of surface sensible and latent heat fluxes from aircraft and surface measurements in FIFE 1987. J. Geophys. Res. 97:18,445-18,453.

MacPherson, J.I., R. Grossman, and R.D. Kelly. 1992. Inter-comparison results for FIFE flux aircraft. J. Geophys. Res. 97:18,499-18,514.

Schuepp, P.H., M.Y. Leclerc, J.I. MacPherson, and R.L. Desjardins. 1990. Footprint prediction of scalar fluxes from analytical solutions of the diffusion equation. Boundary Layer Meteorol. 50:355-373.

Schuepp, P.H., J.I. MacPherson, and R.L. Desjardins. 1992. Adjustment of footprint correction for airborne flux mapping over the FIFE site. J. Geophys. Res. 97:18455-18466.

Sellers, P.J., F.G. Hall, G. Asrar, D.E. Strebel, and R.E. Murphy. 1988. The First ISLSCP Field Experiment (FIFE). Bull. Am. Meteorological Soc. 69:22-27.

Sellers, P.J., and F.G. Hall. 1987. The First ISLSCP Field Experiment (FIFE). FIFE-87 Experiment Plan. GSFC, Greenbelt, Maryland.

Sellers, P.J., and F.G. Hall. 1989. The First ISLSCP Field Experiment (FIFE). FIFE-89 Experiment Plan. GSFC, Greenbelt, Maryland.

Sellers P.J., F.G. Hall, D.E. Strebel, E.T. Kanemasu, R.D. Kelly, B.L. Blad, B.J. Markham, and J.R. Wang. 1990. Experiment design and operations. AMS Symposium on the First ISLSCP Field Experiment (FIFE). Anaheim, CA, February 7-9.

Sellers, P.J., F.G. Hall, D.E. Strebel, R.D. Kelly, S.B. Verma, B.L. Markham, B.L. Blad, D.S. Schimel, J.R. Wang, and E. Kanemasu. 1990. The First ISLSCP Field Experiment (FIFE). FIFE Interim Report. GSFC, Greenbelt, Maryland.

Archive/DBMS Usage Documentation.

Contact the EOS Distributed Active Archive Center (DAAC) at Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee (see the *Data Center Identification Section*). Documentation about using the archive and/or online access to the data at the ORNL DAAC is not available at this revision.

18. Glossary of Terms:

A general glossary for the DAAC is located at Glossary.

19. List of Acronyms:

BPI Byte per inch CCT Computer Compatible Tape CD-ROM Compact Disk (optical), Read-Only Memory DAAC Distributed Active Archive Center EOSDIS Earth Observing System Data and Information System FIFE First ISLSCP Field Experiment FIS FIFE Information System IFC Intensive Field Campaign IFOV Instantaneous Field-of-View ISLSCP International Satellite Land Surface Climatology Project Mbps Megabyte per second MSL Mean Sea Level NAE National Aeronautical Establishment, Note: Renamed The Institute for Aerospace Research (IAR) NRC National Research Council of Canada ORNL Oak Ridge National Laboratory RMS Root Mean Square URL Uniform Resource Locator UTM Universal Transverse Mercator

A general list of acronyms for the DAAC is available at Acronyms.

20. Document Information:

April 27, 1994 (citation revised on October 10, 2002).

This document has been reviewed by the FIFE Information Scientist to eliminate technical and editorial inaccuracies. Previous versions of this document have been reviewed by the Principal Investigator, the person who transmitted the data to FIS, a FIS staff member, or a FIFE scientist generally familiar with the data. It is believed that the document accurately describes the data as collected and archived on the FIFE CD-ROM series.

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