Eddy Corr. Surface Flux: ANL (FIFE)

Summary:

The Eddy Correlation Surface Flux Observations (Argonne) Data Set contains surface flux measurements made at selected sites within the FIFE study area. The surface area and aerological data described here were located at 2 sites in the northwest quadrant of the study area within the Konza Prairie Natural Research area. Both sites were located on hill tops that were burnt on a regular cycle. These data were collected daily only during the five Intensive Field Campaigns which were held during the growing season of 1987 and the projected summer dry down in 1989. Data were also collected using a portable eddy correlation system that moved to a variety of locations within the FIFE study area. These data were collected for a day or two at each location sometime between June 1, 1987 and October 13, 1987.

Argonne National Laboratory did not measure radiation but concentrated on observations of turbulence quantities, primarily covariances and standard deviations of winds, temperature, water vapor, and other quantities. The surface fluxes and standard deviations of carbon dioxide and ozone were measured by Argonne so that the fluxes of mass could be related to each other, surface biophysical conditions, vegetative parameters, and the optical characteristics of the surface that could be detected by remote sensing.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Eddy Corr. Surface Flux: ANL (FIFE).
(Eddy Correlation Surface Flux Observations (Argonne)).

Data Set Introduction:

The Eddy Correlation Surface Flux Observations (Argonne) Data Set contains surface flux measurements made at selected sites within the FIFE study area.

Objective/Purpose:

The combined aim of the surface flux group was to use a network of ground-based observing systems to measure fluxes of heat, water vapor and radiation at a number of points within the FIFE study area. Argonne National Laboratory did not measure radiation but concentrated on observations of turbulence quantities, primarily covariances and standard deviations of winds, temperature, water vapor, and other quantities. The surface fluxes and standard deviations of carbon dioxide and ozone were measured by Argonne so that the fluxes of mass could be related to each other, surface biophysical conditions, vegetative parameters, and the optical characteristics of the surface that could be detected by remote sensing.

Summary of Parameters:

Latent heat flux, sensible heat flux, Bowen ratio, wind speed and direction, air temperature, vapor pressure, friction velocity, carbon dioxide and ozone flux.

Discussion:

Surface flux measurements were made at selected sites within the FIFE study area. The major data collection effort was conducted in 1987 when 6 sites were equipped with eddy correlation instrumentation operated by several different groups. In 1989, surface flux stations were installed at 3 locations within the FIFE study area, respectively. Most surface flux stations were capable of measuring the fluxes of net radiation, sensible heat, and latent heat.

The surface area and aerological data described here were located at 2 sites, one in 1987 and one in 1989. Both sites (station 4, SITEGRID_ID = 2731 in 1987 and station 906, SITEGRID_ID = 2133 in 1989) were located in the northwest quadrant of the study area within the Konza Prairie Natural Research area. Both sites were located on hill tops that were burnt on a regular cycle. These data were collected only during the five Intensive Field Campaigns which were held during the growing season of 1987 and the projected summer dry down in 1989. Data were collected daily during these periods.

Data were also collected using a portable eddy correlation system that moved to a variety of locations within the FIFE study area. These data were collected for a day or two at each location sometime between June 1, 1987 and October 13, 1987.

The data collected using this portable (roving) instrument are found in the GRABBAG directory on FIFE CD-ROM Volume 1.

Related Data Sets:

- Eddy Correlation Surface Flux Observation (USGS).
- Eddy Correlation Surface Flux Observation (UNL).
- Eddy Correlation Surface Flux Observation (GSFC).
- Eddy Correlation Surface Flux Observation (UK).
- Bowen Ratio Surface Flux Observation (GSFC).
- Bowen Ratio Surface Flux Observation (KSU).
- Bowen Ratio Surface Flux Observation (Fritschen).
- Bowen Ratio Surface Flux Observation (Smith).
- Bowen Ratio Surface Flux Observation (UNL).
- Bowen Ratio Surface Flux Observation (USGS).
- FIFE Surface Flux Baseline 92 Derived. Surface Flux Roving - These data were collected using a mobile eddy correlation instrument much like the one used in 1989.

FIS Data Base Table Name:

SURFACE_FLUX_30MIN_DATA.

2. Investigator(s):

Investigator(s) Name and Title:

Dr. Marvin L. Wesely
Argonne National Laboratory

Title of Investigation:

Eddy Flux and Surface Exchange Processes in Non-uniform Areas.

Contact Information:

Contact 1:
Mr. David Cook
Argonne National Lab.
Argonne, IL
Telephone: (708) 252-5840
Email: drcook@anl.gov

Requested Form of Acknowledgment.

The Eddy Correlation Surface Flux Observations (Argonne) were collected and analyzed by M.L. Wesely, D.R. Cook, and R.L. Hart at Argonne National Laboratory. The contribution of these data is appreciated.

3. Theory of Measurements:

Eddy correlation is a well-established technique that has the primary advantage of measuring turbulent diffusive fluxes directly across a near-horizontal plane above the surface. It requires a rigid platform unencumbered by significant aerodynamic obstacles. The fluxes are computed as covariances of the fluctuations of vertical wind velocity with fluctuations of concentration or mixing ratio at the same point and time. Perhaps the most difficult requirement in using eddy-correlation methods to measure fluxes of trace substances is the need for fast-response sensors. For example, suitable sensors have yet to be fully developed for non-methane hydrocarbons, organic sulfur compounds, N2O, NH3, and many other species. Substances for which fast-response sensors are currently available include O3, CO, SO2, CH4, sulfate particles, NO, NO2, and CO2, in addition to wind components, temperature, and water vapor. Some recent technological advancements offer promise for other species.

There is a typical variability of 10% to 20% in flux estimates from half-hour to half-hour for sensors not significantly affected by noise. Considering estimates of some sensor requirements to achieve specified levels of accuracy in eddy-correlation flux estimates from towers (neutral atmospheric stability is assumed and height z is between 1 and 50 m), often the most demanding requirement is for fast response. If we assume a perfectly responding vertical wind sensor co-located with a chemical sensor, and as a rough approximation, we assume that the ratio of horizontal wind speed U to height z is 1 m/s per meter, then, the time constant t (c) should be <0.15 s in order to ensure an accuracy of 10% or better. (A sensor with t (c) = 0.1 s will measure 72% of the variance of the input signal, and its phase will be shifted by 30 deg. at 1 Hz.) Alternatively, the calculated amount of chemical flux found by eddy correlation, in which the chemical sensor has a first-order response time constant of t (c) and delay time of dt, and otherwise ideal characteristics, can be used to correct the measured flux due to the sensor time constant. This procedure becomes increasingly unreliable, however, when attenuation becomes more than about 30%.

A delay time dt, such as might be associated with ducting the air sample from an intake to a sensing chamber, and a separation (d) between the species sensor and the vertical velocity sensor can cause significant flux underestimates. The effects of a delay time can be counteracted by shifting one time series with respect to the other in the analysis procedures. The effects of sensor separation can be minimized by mounting sensors as closely as possible, but this requires that the sensors be small; otherwise aerodynamic flow distortion can result. Small, aerodynamically streamlined sensors also have the advantage of reducing the effects of flow distortion on the measured flux. Poor sensor signal-to-noise ratios also have significant effect on half-hour eddy correlation estimates of vertical flux.

4. Equipment:

Sensor/Instrument Description:

Summary of Eddy Correlation System used by ANL:

- Vertical velocity sensor (path length) CSI sonic: (10 cm)
- Temperature sensor (response time) 12-um Thermocouples: (0.01 s)
- Moisture sensor (response time) ERC Lyman alpha: (0.01 s)
- Sensor height above ground: 12.3 m
- Sampling rate: 20 Hz
- Duty cycle for 30 min averaging period: 86%

The vertical wind speed fluctuations were measured with a single-axis Campbell sonic anemometer, horizontal wind speed with a Frenzen fast-response cup anemometer, temperature with a Campbell microthermocouple, humidity with a Lyman alpha hygrometer, and CO2 content with an open-path infrared absorption sensor. The mean vertical wind speed was measured with a Gill cup anemometer and the mean horizontal wind speed was measured with the cup anemometer. Both of the mechanical wind sensors used a light-chopper base.

Collection Environment:

Ground-based.

Source/Platform:

In 1987 at site 4 (2731-ECA), all of the instruments were extended above the top of the 10 meter walk-up tower at site 4 and were placed at a height of approximately 12.3 m above the local soil surface.

The instrumentation used for the portable (roving) eddy correlation system consisted of a tripod on which all instruments were mounted. The instrument extended above the top of the tripod at heights between two and three meters above the soil surface. The only exception occurred at Site No. 4 on June 1, 1987, when the sensors were placed at a height of 11.7 m, the eddy correlation gear on the 10 meter m walk-up tower.

In 1989, all the instruments were extended above the top of a tripod mast and were at a height of approximately 2.55 m above the soil surface.

Source/Platform Mission Objectives:

To measure fluxes of sensible heat, moisture, carbon dioxide and ozone using the eddy correlation technique.

Key Variables:

Fluxes of sensible heat, latent heat, carbon dioxide, and ozone; air temperature; water vapor pressure; carbon dioxide concentration; ozone concentration; and wind speed and direction.

Principles of Operation:

Fast-response sensors were used for all turbulence quantities measured.

Sensor/Instrument Measurement Geometry:

The fast-response sensors were placed as close together as possible without presenting aerodynamic obstacles to adjacent sensors.

Manufacturer of Sensor/Instrument:

Sonic anemometers:

> Campbell Scientific Instruments
> P. O. Box 551
> Logan, UT 84321.

Propeller anemometer:

> R. M. Young Company
> 2801 Aero Park Drive
> Traverse City, MI 49684
> (modified by Argonne National Laboratory; R. L. Hart).

Cup anemometer:

> Argonne National Laboratory (P. Frenzen)

Fine-wire thermocouple:

> Campbell Scientific Instruments
> P. O. Box 551
> Logan, UT 84321.

Lyman-alpha Hygrometer:

> Electromagnetic Research Corp.
> (modified by Argonne National Laboratory, D. R. Cook and M. L. Wesely).

CO2 sensor:

> Lawrence Livermore Laboratory
> Livermore, CA

(see Bingham, G. E., C. H. Gillespie, and J. H. McQuid. 1978. Development of a Miniature, Rapid Response CO2 sensor. Lawrence Livermore National Laboratory, Report UCRL-52440, Livermore, CA).

O3 sensor:

Analytical Instrument Development, Inc.
Rt. 41 and Newark Rd.
Avondale, PA. 19311
(modified by Argonne National Laboratory, D. R. Cook and M. L. Wesely).

Data logging systems:

DEC and others.

Mean quantities on 10 meter tower in 1987:

Climatronics Corp.
140 Wilbur Place
Airport International Plaza
Bohemia, NY, 11716.

Calibration:

In 1989, a 2 day period was set aside for flux comparisons, including carbon dioxide.

- Sonic anemometer: supplied by the manufacturer.
- Cup and propeller anemometers: calibrated in a wind tunnel.
- Lyman-alpha Hygrometer: calibrated in a chamber in which humidity could be controlled.
- CO2 sensor: calibrated against known standard gases in the field.
- O3 sensor: calibrated against known standard generator in the field.

Specifications:

Not available at this revision.

Tolerance:

Individual fast-response sensors had a response to fluctuations within a tolerance of approximately 10%.

Frequency of Calibration:

All sensors except the carbon dioxide and ozone sensors were calibrated before and after the series of campaigns in 1987, and before and after the field campaign in 1989. The carbon dioxide and ozone sensors were checked daily in the field.

Other Calibration Information:

None.

5. Data Acquisition Methods:

These data were acquired by fast response sensors. At the 10 meter walk-up tower used at site 4 in 1987 and at the 2.5 m tripod in 1989, sensors sampled the atmosphere at a rate of 20 measurements per second. Field computers processed the data in real time to produce preliminary estimates of half-hour averages of means, variances, and covariances.

6. Observations:

Data Notes:

Not available.

Field Notes:

BRIEF DESCRIPTION OF SITE USED BY 10 meter TOWER IN 1987

Site No. 4 (2731-ECA) was located at a burnt, top (BT) area on the Konza Prairie National Park, at an elevation of 445 m. It was co-located with DCP1, Site No. 1(2731-DCP), actually located a few tens of meters to the south. The 10 meter walk-up tower was placed approximately 10 m south of the northern intersection of the two roads that separate area 1D from 2D. Area 1D was burnt in the spring of 1987; area 2D was not burnt that year. All other areas nearby were unburned areas.

The "footprint" of the surface sampled covered different areas, determined by wind direction. With wind directions between approximately 180 and 240 deg, burnt areas were sampled, otherwise unburned areas. Near 180 deg, oscillations in flux values might correspond to fairly small shifts in wind direction.

BRIEF DESCRIPTION OF SITES USED BY ROVER SETUP IN 1987

Sites were used for each deployment, at the sites, times, and locations are given below. The sensor array was frequently turned into the wind to minimize flow distortions by sensor supports. The symbols used below are described at other locations in FIS and in the FIFE Interim Report, and all times are CDT.

Site No. Station Deployment [old name] Type Start/Stop Local positioning of sensors

4 (2731-ECA) BT 1200 1-JUN/ At top of 10 meter tower, next to ANL

[EC/A] 2030 1-JUN stationary eddy flux gear; surfaces sampled included BT, UT, and UM with varying aspects, depending on wind direction.

4 (2731-ECA) BT 1300 3-JUN/ 200 m south of 10 meter tower on BT but near [EC/A] 0630 5-JUN the border with UT; BT of area 1D sampled with a westerly wind component (180 through 360 deg.), but UT of 2D sampled with other wind directions.

44 (2043-BRL) BT 1430 5-JUN/ In fence-in area with Bowen ratio [BR/L3] 1530 6-JUN station; the southerly winds that prevailed gave a maximum upwind fetch of 100 m in front of a steep, south-facing slope.

6 (2132-BRK) UMn 1300 1-JUL/ 20 m south of site 6 array, on the top [BR/KS2] 0930 3-JUL of a knoll; with the southerly winds that prevailed, a southeast-facing slope of approximately 2% grade was sampled.

38 (1478-BRS) BMe 1330 3-JUL/ Close to the FSU gear, in a hilly area; [BR/ES2] 2400 3-JUL with the southeast winds that prevailed, the upwind grade was approximately 2%.

4 (2731-ECA0 BT 0900 11-JUL/ 25 m SSW of the 10 meter tower and co-located [EC/A] 0030 12-JUL with KSU rover; with the southerly winds that prevailed, unburned top was sampled almost exclusively.

42 (1445-BRL) BSn 1330 9-AUG/ In fenced-in area with Bowen ratio [BR/L2] 1630 11-AUG station; with the highly variable wind directions, flow upslope, downslope, and normal to the slope were sampled.

44 (2043-BRL) BT 1100 15 AUG/ In fenced-in area with Bowen ratio [BR/L3] 1330 17 AUG station; when southerly winds prevailed, the maximum upwind fetch was 100 m in front of a steep, south-facing slope; winds were from the north and east at times.

16 (4439-ECV) BT 1530 17-AUG/ Next to UNL's eddy correlation gear; [EC/S] 1600 21-AUG southerly flow with good fetch occurred most of the time. No data on Aug. 18.

26 (8739-ECB) BT 1400 6-OCT/ Near UK 's sensing systems, on [EC/UK] 1100 9-OCT west edge of fenced-in area; northerly winds with good fetch occurred on Oct. 6, 7, & 9, but winds were southeasterly from a moderate slope on Oct. 8.

28 (6943-ECW) BMe 1400 11-OCT/ In southeast corner of fenced-in area [EC/GS2] 1700 13-OCT near USGS's gear; variable wind directions sometimes had flow coming of steep upward slope to the west.

BRIEF DESCRIPTION OF SITE USED IN 1989

Site No. 906 (2133-ECA) was located at a burnt, top (BT) area on the Konza Prairie National Park, at an elevation of 443 m. It was co-located with Bowen ratio Site No. 904 (2133-BRL) which was a few meters east of the 906 site. PAM Site No. 931 (2133-PAM) was located a few tens of meters to the north.

Sites 906 and 904 straddled the apex of the WAB-zone. At the end of the WAB-zone (100 m from the two sites), a steep south-facing slope existed in directions west of 160 degrees from the sites. This slope was on the southern side of a gully that became deeper and wider toward the west, where the slope became more westerly facing.

The eddy flux values were affected by surface conditions that extended well beyond the WAB zone. A gully upwind began at about 160 degrees from the apex of the WAB and became very large by about 210 degrees. Therefore, the eddy correlation gear was probably sampling some of the steep, south-facing slope when winds were from this direction interval. Farther west, the area opened up and the slope became more west-facing.

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:

The eddy correlation tower was located at a fixed location within the FIFE site as indicated below:

SITEGRID	STN	LATITUDE	LONGITUDE	EASTING	NORTHING	ELEV	SLOPE	ASPECT
2731-ECA	4	39 05 01	-96 33 34	711110	4328678	446		
2133-ECA	906	39 05 34	-96 33 12	711604	4329726	443	1	TOP

Spatial Coverage Map:

Not available.

Spatial Resolution:

These are point data except that the effective surface sampled by the instrumentation mounted on the 10 meter tower in 1987 at site 4 extended to approximately 1 km upwind. The surface sampled covered different areas, determined by wind direction.

In 1989, the effective surface sampled by the instrumentation mounted at 2.5 m above the canopy extended over 200 m upwind of the sensors. The types of surfaces sampled could vary greatly with wind direction.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

These data were collected during the five Intensive Field Campaigns, May 26 - June 6, June 25 - July 12, August 5 - 21, October 5 - 17, all in 1987, and July 24 - August 13, 1989. There are 77 days of data. Data at the two stations covers the time range listed below.

- Station 4: May 26, 1987 - October 17, 1987
- Station 906: July 24, 1989 - August 13, 1989.

Temporal Coverage Map:

Not available.

Temporal Resolution:

The data values reported are 30 minute averages. During the IFC's, data were collected daily.

Data Characteristics:

The SQL definition for this table is found in the SF_30MIN.TDF file located on FIFE CD-ROM Volume 1. The following chart lists the four key surface flux variables, and only those other variables that are contained in the data set described in this document.

Parameter/Variable Name

Parameter/Variable Description **Range** **Units**
Source

SITEGRID_ID This is a FIS grid location code. Site grid codes (SSEE-III) give the south (SS) and the east (EE) cell number in a 100 x 100 array of 200 m square cells. The last 3 characters (III) are an instrument identifier.	
STATION_ID The station ID designating the location of the observations.	
OBS_DATE The date of the observations, in the format (DD-mmm-YY).	
OBS_TIME The time that the observation was taken, in GMT. The format is HHMM.	[GMT]
LATENT_HEAT_FLUX The latent heat flux, the flux of the energy due to the evaporation of water.	[Watts] [meter^-2]
NET_RADTN The net radiation, including both downward and upward energy.	[Watts] [meter^-2]
SENSIBLE_HEAT_FLUX The sensible heat flux, the flux of the energy due to temperature differences.	[Watts] [meter^-2]
SOIL_HEAT_FLUX The surface soil heat flux, the flux of energy into the soil.	[Watts] [meter^-2]
BOWEN_RATIO The Bowen Ratio, the ratio of the SENSIBLE_HEAT_FLUX to the LATENT_HEAT_FLUX.	
WIND_SPEED The average wind speed in this 30 minutes.	[meters] [sec^-1]

WIND_DIR The average wind direction in this 30 minutes.	[degrees from North]
WIND_SPEED_HOR_SDEV The standard deviation for the horizontal wind speed.	[meters] [sec^-1]
WIND_SPEED_VERT_SDEV The standard deviation for the vertical wind speed.	[meters] [sec^-1]
AIR_TEMP_MEAN The mean air temperature in this 30 minutes.	[degrees Celsius]
AIR_TEMP_MEAN_SDEV The standard deviation for the mean air temperature.	[degrees Celsius]
VAPOR_PRESS_MEAN The mean vapor pressure in this 30 minutes.	[kiloPascals]
VAPOR_PRESS_SDEV The standard deviation for the vapor pressure.	[kiloPascals]
FRICTION_VELOC The friction velocity. [sec^-1]	[meters]
CO2_CONTENT The carbon dioxide content of the air.	[ppm by volume]
OZONE_CONTENT The ozone content of the air. by volume]	[ppm
CO2_CONTENT_SDEV The standard deviation of carbon dioxide content.	[ppm by volume]
OZONE_CONTENT_SDEV	

The standard deviation of ozone content.	[ppm by volume]
CO2_FLUX The carbon dioxide flux. [meter^-2] [sec^-1]	[mg]
OZONE_FLUX The ozone flux. [cm^-1] [sec^-1]	[ppb]
FIFE_DATA_CRTFCN_CODE The FIFE Certification Code for * the data, in the format: CGR Certified by Group), CPI (Certified by PI), CPI-??? (CPI - questionable data).	
LAST_REVISION_DATE data, in the format (DD-MMM-YY).	

Footnotes:

* 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 is "merged" from two separate receiving stations to eliminate transmission errors. CPI-??? Investigator thinks data item may be questionable.

** There are several missing value indicators in each column. The values may be positive or negative 9.9, 9.99, 99.99, 999, 999.99, 9999 or 99999.99.

Sample Data Record:

The following sample record contains all the fields in the surface flux record but only those fields that are described here (i.e., reported by M.L. Wesely) contain data.

SITEGRID_ID	STATION_ID	OBS_DATE	OBS_TIME	LATENT_HEAT_FLUX
2133-ECA	906	04-AUG-89	145	-46.4
2133-ECA	906	04-AUG-89	215	-38.9
2133-ECA	906	04-AUG-89	245	-40.6
2133-ECA	906	04-AUG-89	315	-40.8

NET_RADTN	SENSIBLE_HEAT_FLUX	SOIL_HEAT_FLUX	DIFFUSE_SOLAR_RADTN_DOWN
36.9			
29.1			
30.4			
30			

SOLAR_RADTN_DOWN	SOLAR_RADTN_UP	SOLAR_RADTN_NET	SOLAR_RADTN_DOWN_SDEV

SOLAR_RADTN_UP_SDEV	PAR_DOWN	PAR_UP	SURF_ALBEDO

LONGWAVE_RADTN_DOWN	LONGWAVE_RADTN_UP	LONGWAVE_RADTN_NET

BB_TEMP_LONGWAVE_DOWN	BB_TEMP_LONGWAVE_UP	TOTAL_RADTN_DOWN

TOTAL_RADTN_UP	SOIL_HEAT_FLUX_0_TO_5CM	SOIL_HEAT_FLUX_5_TO_10CM

SOIL_HEAT_FLUX_10_TO_20CM	HEAT_STORAGE	SOIL_WATER_POTNTL_0_TO_5CM

SOIL_WATER_POTNTL_5_TO_20CM	SURF_RADIANT_TEMP	SURF_RADIANT_TEMP_SDEV

SOIL_TEMP_0_TO_25MM	SOIL_TEMP_25MM_TO_5CM	SOIL_TEMP_5_TO_10CM

SOIL_TEMP_10_TO_20CM	SOIL_TEMP_20_TO_50CM	RAINFALL	BOWEN_RATIO
-.795			
-.748			
-.749			
-.735			

WIND_SPEED	WIND_DIR	WIND_SPEED_MIN	WIND_SPEED_MAX	WIND_SPEED_SDEV
6.86	-9999			
7.65	-9999			
7.75	-9999			
8.44	-9999			

WIND_DIR_SDEV	TIME_WIND_SPEED_MIN	TIME_WIND_SPEED_MAX

TIME_WIND_DIR_MIN	TIME_WIND_DIR_MAX	WIND_SPEED_HOR_MEAN

WIND_SPEED_LAT_MEAN	WIND_SPEED_VERT_MEAN	WIND_SPEED_HOR_SDEV
1.37		
1.41		
1.49		
1.59		

WIND_SPEED_LAT_SDEV	WIND_SPEED_VERT_SDEV	AIR_TEMP_LOW	AIR_TEMP_HIGH
.531			

.561
.579
.61

AIR_TEMP_OTHER	AIR_TEMP_MEAN	AIR_TEMP_MEAN_SDEV	AIR_TEMP_OTHER_SDEV
-9999	.17		
-9999	.144		
-9999	.162		
-9999	.167		

DELTA_TEMP	WET_BULB_TEMP_LOW	WET_BULB_TEMP_HIGH	VAPOR_PRESS_LOW

VAPOR_PRESS_HIGH	VAPOR_PRESS_MEAN	VAPOR_PRESS_SDEV	REL_HUMID_LOW
-9999	.014		
-9999	.012		
-9999	.013		
-9999	.014		

REL_HUMID_HIGH	REL_HUMID_SDEV	SURF_AIR_PRESS	FRICTION_VELOC
.488			
.483			
.487			
.488			

W_T_MEAN	W_E_MEAN	CO2_CONTENT	OZONE_CONTENT	CO2_CONTENT_SDEV
337	-9999	1		
340	-9999	1		
338	-9999	1		
335	-9999	1		

OZONE_CONTENT_SDEV	CO2_FLUX	OZONE_FLUX	FIFE_DATA_CRTFCN_CODE
-9999	-.25	-9999	CPI
-9999	-.18	-9999	CPI
-9999	-.19	-9999	CPI
-9999	-.16	-9999	CPI

LAST_REVISION_DATE
01-OCT-91
01-OCT-91
01-OCT-91
01-OCT-91

8. Data Organization:

Data Granularity:

These are point data except that the effective surface sampled by the instrumentation extended to approximately 1 km upwind. The data values reported are 30 minute averages. During the IFC's, data were collected daily.

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 begin 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, and principal investigator name.

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.)

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:

Formulas included statistical procedures for computing means, variances, standard deviations, and covariances of signals obtained. Coordinate rotations were simple geometrical transformations.

Data Processing Sequence:

Processing Steps:

Means, variances, and covariances were computed in the field and these were manipulated after the field campaigns to produce covariances corresponding to a mean vertical wind speed of zero.

Processing Changes:

None.

Calculations:

Special Corrections/Adjustments:

Computational adjustments were made to compensate for spatial separation of sensors and limited frequency responses of sensors. In addition, the Webb et al. correction for the effects of temperature-induced density fluctuations was applied to the estimates of latent heat flux, and the Webb et al. corrections for the effects of density fluctuations caused by both temperature and humidity variations were applied to the estimates of CO_2 flux.

Calculated Variables:

Not available.

Graphs and Plots:

None.

10. Errors:

Sources of Error:

Electronic noise in the ozone and the carbon dioxide sensors could result in errors in standard deviation of parameters. Also see the *Theory of Measurements Section* for a discussion of potential errors in these data.

Quality Assessment:

It was recognized early in the study that standardization's of "constant" (e.g., physical constants of the air, psychrometric constant, etc.), methods of computation, integration and reporting time, etc. were necessary. These were agreed upon in planning sessions. Preliminary data sets were compared among stations and instruments from different manufacturers for estimating net radiation, soil heat flux, water vapor density, temperature, solar radiation, and wind speed, it was necessary to have confidence that differences in observations were due to site differences and not due to instrumentation.

Data Validation by Source:

The Hydrological Sciences Branch at NASA Goddard Space Flight Center was given the responsibility to compare flux data from all flux stations. This served two purposes: 1) as a data quality check, and 2) a preliminary analysis of site differences.

Confidence Level/Accuracy Judgment:

The following are the best estimates of accuracy for a single flux estimate:

- Net radiation +/- 4 to 7%
- Soil heat flux +/- 30%
- Latent heat flux +/- 15 to 20 % or +/-30 [W][m^-2], whichever is larger
- Sensible heat flux +/- 15 to 20 % or +/-30 [W][m^-2], whichever is larger

None of these estimates addresses the variability of flux estimates from site-to-site.

Measurement Error for Parameters:

No quantitative assessment was made, see the *Confidence Level/Accuracy Judgment Section*.

Other errors mentioned in the *Sources of Error Section* above were not quantified or are quantified in the *Theory of Measurements Section*.

Additional Quality Assessments:

Several of the key surface flux parameters have undergone extensive intercomparison and examination for spikes in the data. The data have also been checked for an imbalance in the energy equation. Details of these analyses are described in the Surface Flux Baseline 1992 on FIFE CD-ROM Volume 1.

FIS staff applied a general Quality Assessment (QA) procedure to some of the fields in this data set 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 numerical field. 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 that 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 datasets 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 dataset. 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:

Because of electronic noise in the ozone and the carbon dioxide sensors in 1987, estimates of the associated standard deviation are excessively large and do not represent atmospheric conditions most of the time.

Several different missing values are used within each column. They can be positive or negative 9.9, 9.99, 99.99, 9999, or 99999.99.

The missing value indicators in the following fields may have been inadvertently converted to 1000. Use these data with caution.

Name	Name
DIFFUSE_SOLAR_RADTN_DOWN	TOTAL_RADTN_DOWN
SOLAR_RADTN_DOWN	TOTAL_RADTN_UP
SOLAR_RADTN_UP	HEAT_STORAGE
SOLAR_RADTN_NET	RAINFALL
SOLAR_RADTN_DOWN_SDEV	WIND_DIR_MIN
SOLAR_RADTN_UP_SDEV	WIND_DIR_MAX
LONGWAVE_RADTN_DOWN	CO2_CONTENT
LONGWAVE_RADTN_UP	O3_CONTENT
LONGWAVE_RADTN_NET	CO2_STDEV
BB_TEMP_LONGWAVE_DOWN	O3_STDEV
BB_TEMP_LONGWAVE_UP	

Usage Guidance:

Caution should be exercised when using flux data for several hours surrounding dawn and dusk since these are periods of unsteady conditions. In addition, nighttime data should be closely scrutinized.

Any Other Relevant Information about the Study:

None.

12. Application of the Data Set:

The surface fluxes and standard deviations of carbon dioxide and ozone in this data set were measured by Argonne so that the fluxes of mass could be related to each other, surface biophysical conditions, vegetative parameters, and the optical characteristics of the surface that could be detected by remote sensing.

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:

Eddy Correlation Surface Flux Observations (Argonne) data are available on FIFE CD-ROM Volume 1. The CD-ROM filename is as follows:

\DATA\SUR_FLUX\30_MIN\GRIDxxxx\YyyMmm\ydddgrid.ECA or
\DATA\SUR_FLUX\30_MIN\GRIDxxxx\Yyyyy\ydddgrid.ECA

Where *xxxx* is the four digit code for the location within the FIFE site grid, *yy* is the last two digits of the year (e.g., Y87 = 1987), *yyyy* is the four digits of the century and year (e.g., Y1987 = 1987), *mm* is the month of the year (e.g., M12 = December), and *ddd* is the day of the year, (e.g., 061 = sixty-first day in the year). 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: *ydddgrid.sfx*, where *grid* is the four-number code for the location within the FIFE site grid, *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 .ECA for this data set.

17. References:

Satellite/Instrument/Data Processing Documentation.

Kanemasu, E.T., S.B. Verma, E.A. Smith, L.J. Fritschen, M.L. Wesely, R.T. Field, W.P. Kustas, H.L. Weaver, J.B. Stewart, R.J. Gurney, G.N. Panin, and J.B. Moncrieff. 1992. Surface flux measurements in FIFE: An overview. J. Geophys. Res. 97:18547-18555.

Journal Articles and Study Reports.

Desjardins, R.L., R.L. Hart, J.I. MacPherson, P.H. Schuepp, and S.B. Verma. 1992. Aircraft and tower-based fluxes of carbon dioxide, latent and sensible heat. J. Geophys. Res. 97:18,477-18,485.

Fritschen, L.J., P. Qian, E.T. Kanemasu, D. Nie, E.A. Smith, J.B. Stewart, S.B. Verma and M.L. Wesely. 1992. Comparison of surface flux measurement systems used in 1989. J. Geophys. Res. 97:18,697-18,713.

Gao, W., M.L. Wesely, D.R. Cook, and R.L. Hart. 1992. Dry air-surface exchange in hilly terrain. p. 661-673. In: Proceedings of the Fifth International Conference on Precipitation

Scavenging and Atmosphere-Surface Exchange Processes. [eds.] W.G. Slinn and S.E. Schwartz, Hemisphere Pub. Corp. pp. 1808.

Gao, W., M.L. Wesely, D.R. Cook, and R.L. Hart. 1992. Air-surface exchange of H2O, CO2, and O3 at a Konza site in relation to remotely sensed vegetation indices. J. Geophys. Res. 97:18,663-18,671.

Moncrieff, J.B., S.B. Verma, and D.R. Cook. 1992. Intercomparison of eddy correlation carbon dioxide sensors during FIFE'89. J. Geophys. Res. 97:18,725-18,730.

Nie, D., R.T. Field, L.J. Fritschen, E.T. Kanemasu, W.P. Kustas, E.A. Smith, J.B. Stewart, S.B. Verma, and H.L. Weaver. 1991. An intercomparison of surface energy flux measurement systems used during FIFE. J. Geophys. Res. 97:18,715-18,724.

Smith, E.A., A.Y. Hsu, W.L. Crosson, R.T. Field, L.J. Fritschen, R.J. Gurney, E.T. Kanemasu, W.P. Kustas, D. Nie, W.J. Shuttleworth, J.B. Stewart, S.B. Verma, H.L. Weaver, and M.L. Wesely. 1992. Area averaged surface fluxes and their time-space variability over the FIFE experimental domain. J. Geophys. Res. 97:18,599-18,622.

Wesely, M.L., D.H. Lenschow, and O.T. Denmead. 1989. Flux measurement techniques. In: Global Tropospheric Chemistry-Chemical Fluxes in the Global Atmosphere. pp. 31-46. National Center for Atmospheric Research. Boulder, CO. 107 pp.

Wesely, M.L., and B.B. Hicks. 1976. High-frequency temperature and humidity correlation above a warm, wet surface. J. Appl. Meteorol. 17:123-128.

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:

ANL Argonne National Laboratory CD-ROM Compact Disk (optical), Read-Only Memory CSI Campbell Scientific Inc. DAAC Distributive Active Archive Center DCP Data Control Platform EOSDIS Earth Observation System Data and Information System ERC Electromagnetic Research Corp. FIFE First ISLSCP Field Experiment FIS FIFE Information System ISLSCP International Satellite Land Surface Climatology Project LAI Leaf area index ORNL Oak Ridge National Laboratory PAMS Portable Automatic Mesonet Station REBS Radiation and Energy

Balance Systems UTM Universal Transverse Mercator WAB Wind Aligned Blob URL Uniform Resource Locator

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

20. Document Information:

April 28, 1994 (citation revised on October 15, 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.

Document Review Date:

October 23, 1996.

Document ID:

ORNL-FIFE_SF30_ECA.

Citation:

Cite this data set as follows:

Wesely, M. L. 1994. Eddy Corr[elation]. Surface Flux: ANL (FIFE). Data set. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/30. Also published in D. E. Strebel, D. R. Landis, K. F. Huemmrich, and B. W. Meeson (eds.), Collected Data of the First ISLSCP Field Experiment, Vol. 1: Surface Observations and Non-Image Data Sets. CD-ROM. National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland, U.S.A. (available from http://www.daac.ornl.gov).

Document Curator:

DAAC Staff

Document URL:

http://daac.ornl.gov