Eddy Corr. Surface Flux: USGS (FIFE)

Summary:

Surface flux measurements were made at selected sites within the FIFE area. Each surface flux station was capable of measuring the fluxes of net radiation, sensible heat, and latent heat. The data contained in the Eddy Correlation Surface Flux Observations (USGS) Data Set were collected from two sites located in the northwest and southwest quadrants on slight inclines in the FIFE study area. These data are available only during the four Intensive Field Campaigns, held during the growing season of 1987, May 25 - October 17. During this period there are 66 days of data.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Eddy Corr. Surface Flux: USGS (FIFE)
(Eddy Correlation Surface Flux Observations (USGS)).

Data Set Introduction:

The data contained in the Eddy Correlation Surface Flux Observations (USGS) Data Set were collected from two sites located in the northwest and southwest quadrants on slight inclines in 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.

Summary of Parameters:

Latent heat flux, net radiation, sensible heat flux, soil heat flux, incoming solar radiation, outgoing solar radiation, heat storage, soil temperature, Bowen ratio, wind speed and direction, air temperature, vapor pressure, and friction velocity.

Discussion:

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

The data described here were located from two sites in the FIFE study area. The sites were located in the northwest (site 22, SITEGRID_ID = 4609) and southwest (site 28, SITEGRID_ID = 6943) quadrants on slight inclines (3 deg and 7 deg), respectively. These data are available only during the four Intensive Field Campaigns, held during the growing season of 1987, May 25 - October 17. During this period there are 66 days of data.

Related Data Sets:

- Eddy Correlation Surface Flux Observation (UNL).
- Eddy Correlation Surface Flux Observation (GSFC).
- Eddy Correlation Surface Flux Observation (UK).
- Eddy Correlation Surface Flux Observation (Argonne).
- 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).

FIS Data Base Table Name:

SURFACE_FLUX_30MIN_DATA.

2. Investigator(s):

Investigator(s) Name and Title:

Dr. Harold L. Weaver
United States Geological Survey

Title of Investigation:

FIFE observations of surface fluxes.

Contact Information:

Contact 1:
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David I. Stannard
U. S. Geological Survey-WRD
Denver, CO
Tel. (303) 236-4983

Requested Form of Acknowledgment.

Please include reference to the following in any presentations or papers making use of these data:

Weaver, H.L. 1990. Temperature and humidity flux-variance relations determined by one-dimensional eddy correlation. Boundary-Layer Meteorol. 53: 77-91.

3. Theory of Measurements:

Eddy correlation is the most direct micrometeorological technique for measuring turbulent fluxes in the surface layer of the atmospheric boundary layer. It is direct in that it involves fewer assumptions than other methods. Some remaining assumptions are that sensors have fast response and the measurement site is horizontally homogeneous enough to avoid measurement problems associated with adjective fluxes and terrain-induced flow distortion.

The eddy-correlation computation of SENSIBLE_HEAT_FLUX is the product of the volumetric heat capacity of air and the covariance between vertical wind speed and air temperature. The covariance between vertical wind speed and air temperature is separately entered as W_T_MEAN. LATENT_HEAT_FLUX is calculated as the product of the latent heat of vaporization and the covariance between vertical wind speed and humidity. This covariance is also entered as W_E_MEAN.

4. Equipment:

Sensor/Instrument Description:

Summary of Eddy Correlation System used by USGS:

- Net radiation sensor: Swissteco
- Soil heat flux sensor: CSI modified Peltier cooler
- Upper layer heat storage sensor: Four-probe thermocouples in parallel
- Vertical velocity sensor (path length): CSI sonic (10 cm)
- Temperature sensor (response time): 12-um Thermocouple (0.01 s)
- Moisture sensor (response time): CSI Lyman alpha (0.01 s) for IFC-1, -2; CSI krypton KH-20 (0.01 s), for IFC-3, -4
- Sensor height above ground: 1.6 m (4609-ECW), 1.1 m (6943-ECW)
- Sampling rate: 10 Hz
- Duty cycle for 30 min averaging period: 100%

All eddy correlation measurements used a single-axis Campbell sonic anemometer for vertical wind speed (w) and air temperature(T). Prior to August, 1987, Lyman-alpha hygrometers were used to measure humidity. Campbell Scientific Inc. made these and the KH-20 Krypton hygrometers that replaced them in August. Webb et al. (1980) adjustments have been applied.

Collection Environment:

Ground-based.

Source/Platform:

Ground: instruments supported by combinations of tripods and vertical and horizontal pipe supports. For heights above the ground, see the *Field Notes Section*.

Source/Platform Mission Objectives:

Not available.

Key Variables:

Not available.

Principles of Operation:

Sonic Anemometer:

The Campbell sonic anemometer system used obtains the velocity fluctuations of vertical wind speed from the measured doppler shift induced by the wind velocity on an ultra-sonic frequency pulse broadcast across a 10 cm path. The effect of temperature on sound velocity is eliminated by determining the doppler frequency from the difference between forward and reverse path observations. Electronic processing of the signals from the ultra-sonic transducers produces a real-time output voltage in the range +/- 4 V DC analog to the observed wind velocity. The value of the output is subject to environment-ally induced deviations corresponding to diurnal temperature changes. Therefore, only the fluctuating values derived from mean values calculated over time intervals on the order of one hour are considered reliable.

Air temperature for the Campbell Scientific eddy correlation system is measured with fine wire thermocouple mounted about 4 cm from the anemometer sound path. The thermocouple output is amplified to a +/- 4.0 volt signal. The thermocouple temperature is referenced to the instrument case which is thermally lagged to respond slowly to diurnal temperature changes. Consequently, the useful output is temperature fluctuation derived from mean values calculated over sampling intervals on the order of one half hour.

Absorption hygrometer:

The Campbell Scientific absorption hygrometer measures the ultra-violet light transmission across a nominal 1 cm path in a water vapor absorption band corresponding to a krypton emission line (Campbell and Tanner, 1985). Instrument response is at least sufficient to resolve fluctuations of 80 Hz. The instrument output is a voltage in the range 0 to 4 V dc. The signal strength is subject to gradual diminution due to scale accumulation on the optical surfaces. Consequently, the useful output is fluctuation of water vapor density around mean values calculated over sampling intervals on the order of one hour.

Soil Heat Flux Transducer:

An encapsulated thermopile yields a voltage output proportional to the temperature difference across the top and bottom surfaces. The device has been calibrated in terms of heat flux through transducer corresponding to the observed temperature difference.

Sensor/Instrument Measurement Geometry:

The eddy correlation data represents an area ranging from about 0.01 ha for very stable atmospheric conditions to about 1 ha for unstable and some neutral atmospheric conditions.

Sonic anemometer - hygrometer separation: 10 cm

Manufacturer of Sensor/Instrument:

Sonic anemometers:

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

Fine-wire thermocouple:

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

Lyman-alpha Hygrometer:

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

Krypton Hygrometer:

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

Soil heat transducer:

Made by investigator (Weaver and Campbell, 1985).

Soil thermocouples:

Made by investigators.

Pyranometer (outgoing shortwave radiation):

Eppley Laboratories
Newport, RI.

Pyranometer, silicon (incoming shortwave radiation):

LI-COR, Inc.
Lincoln, Nebraska.

Net radiometer:

Swissteco Pty., Ltd.
Melbourne Vic. Australia 31.

Cup anemometer, #03001:

R. M. Young.

Calibration:

Specifications:

Not provided by Principal Investigator.

Tolerance:

Not available at this revision.

Frequency of Calibration:

Varies according to sensor. About every two years for net radiometers (shortwave), soil heat transducers, and open-path hygrometers. Less often for other classes of sensors.

Other Calibration Information:

- Soil heat flux plates were calibrated in several laboratories under different conditions.
- Soil heat transducers were last calibrated in 1986 by P.J.Pinter, USDA Water Conservation Laboratory, Phoenix, Arizona.
- Net radiometer (shortwave) calibration checked against pyranometer by shading method.
- Sonic anemometer: supplied by manufacturer.
- Lyman-alpa hygrometer: in fixed humidity chamber by investigator.
- Krypton hygrometer: supplied by manufacturer.
- Soil heat transducer: by investigator (Weaver and Campbell 1985).
- Cup anemometer: supplied by manufacturer.
- Net radiometer: supplied by manufacturer.
- Pyranometer: supplied by manufacturer.

5. Data Acquisition Methods:

The data were acquired with Campbell 21x data loggers and transferred to cassette tapes. A single computer program used 21x data as input to output the data files on disc. All quality controls and algorithms are formal and explicit in the processing programs, written in Pascal.

The standard deviation of air temperature was obtained from a fine-wire thermocouple on the sonic anemometer, and the standard deviation of vapor pressure was measured with a fast-response wet-bulb psychrometer. During IFC-3 and IFC-4, the standard deviations of vapor pressure were obtained from the Campbell Scientific KH-20 krypton hygrometer used in eddy-correlation measurements of vapor flux. During periods when the weather prevented eddy-correlation measurements, the standard deviations of vapor pressure and air temperature were obtained from the fast-response wet-bulb psychrometer. Friction velocity was calculated from wind measurement at a single height and an estimate of surface roughness (0.03 m).

6. Observations:

Data Notes:

Not available.

Field Notes:

SURFACE FLUX SITE 22:

Site 22 (4609-ECW) had a Campbell Scientific eddy correlation system set up on a 3 degree slope with E exposure. The slope was approximately a plane surface. A gravel road about 70 m SW of the site probably affected flux measurement very little. There was a PAM station about 60 m S and 8 degrees W. During IFC-1 the measurement site was almost collocated with the PAM station, the latter being 10 m NE of the site. Site 22 was moved farther away from the road for IFCs 2, 3, and 4 to further reduce its effects on flux measurements.

All measurements were made normal to the 3 degree slope except for radio-meter measurements.

Instrument and vegetation heights:

Measurement	Height (m)			
	IFC-1	**IFC-2**	**IFC-3**	**IFC-4**
Net radiation	1.73	1.80	1.21	1.20
Wind*Temperature mean	2.03	2.00	1.92	1.90
Wind*Vapor pressure mean	2.03	2.00	1.92	1.90
Vapor pressure	2.74	2.10	2.74	2.90
Air temperature	2.74	2.10	2.74	2.90
Soil Temp depth 1	-0.025	-0.025	-0.025	-0.025
Soil Temp depth 2	-0.10	-0.10	-0.10	-0.10
Soil Temp depth 3	-0.50	-0.50	-0.50	-0.50
Soil heat flux	-0.05	-0.05	-0.05	-0.05
Wind speed	2.33	2.30	2.41	2.40
Vegetation	0.35	0.40	0.40	0.40

Negative values indicate depth below ground.

SURFACE FLUX SITE 28:

Site 28 had a Campbell Scientific eddy correlation system set up on a 7 degree slope with E exposure. The slope was not a plane surface. A hill to the W with approx. 20 deg slope created a grade break about 30 m W of the site. Contours curved such that the slope N of the site had a more NE exposure and the slope S of the site had a SE exposure. Scattered trees from NE to SE of the site interfered with ideal fetch. All measurements were made normal to the 7 degree slope except for radiometer measurements. During IFC-2, there was a rotation of the eddy correlation system, which did not avoid problems with flux recovery; but daytime flux recovery was generally between 80% and 120% during this period. Since the net radiometer was level, rather than parallel to the slope, it tended to underestimate available energy normal to the slope in the morning and to overestimate available energy normal to the slope in the afternoon. When comparing fluxes of sensible heat and water vapor with those measured normal to the geopotential they should be multiplied by 1/cos (7 deg) or 1.0075. This small correction is left to the data uses to make.

During Aug. 5-12, 1987, all thermocouple measurements required some adjustment because a voltage offset in the data logger affected single-ended measurement of millivolt-range signals. The correction for this voltage offset was determined mainly at night from the non-zero values of pyranometers. Large daytime changes in the voltage offset could be closely estimated from changes in the soil temperature signal at 50 cm. Small daytime changes in the voltage offset went undetected, resulting in inaccuracies in the temperature measurements reported from Site 28 during this 8-day period.

Instrument and vegetation heights:

Measurement	**Height (m)**				
	IFC-1	**IFC-2**	**IFC-3**	**IFC-4**	
				Oct 3-9	Oct 10-27
Net radiation	0.90	1.15	1.11	0.93	0.93
Wind*Temperature mean	1.35	1.65	1.59	1.80	1.08
Wind*Vapor pressure mean	1.35	1.65	1.59	1.80	1.08
Vapor pressure	1.88	2.00	2.02	2.20	1.39
Air temperature	2.74	2.10	2.02	2.20	1.39
Soil Temp depth 1	-0.025	-0.025	-0.025	-0.025	-0.025
Soil Temp depth 2	-0.10	-0.10	-0.10	-0.10	-0.10
Soil Temp depth 3	-0.50	-0.50	-0.50	-0.50	-0.50
Soil heat flux	-0.05	-0.05	-0.05	-0.05	-0.05
Wind speed 1	.70	2.00	2.10	2.30	1.59
Vegetation	0.30	0.35	0.35	0.30	

Negative values indicate depth below ground.

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:

These data were obtained at the following locations within the FIFE study area.

SITEGRID	STN	LATITUDE	LONGITUDE	EASTING	NORTHING	ELEV (FT)	SLOPE (DEG)	ASPECT

--------	----	--------	---------	-------	--------	----	-----	------
4609-ECW	22	39 03 02	-96 36 41	706705	4324890	390	3	EAST
6943-ECW	28	39 00 22	-96 32 04	713500	4320147	415	7	EAST

Station 22 (4609-ECW) was located in the Northwest quadrant of the FIFE study area along the southern boundary of this quadrant, and station 28 (6943-ECW) was located in the southwest quadrant along the eastern boundary of this quadrant. Station 22 was located on a 3 degree slope with an eastern exposure. Station 28 was located on a 7 degree slope with an eastern exposure.

Spatial Coverage Map:

Not available.

Spatial Resolution:

These are point data. However, the eddy correlation data represents an area ranging from about 0.01 ha for very stable atmospheric conditions to about 1 ha for unstable and some neutral atmospheric conditions.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

Surface flux data were collected at sitegrids 4609 and 6943 from May 25, 1987 to October 17, 1987. During this period there are 66 days of data. Data are available only during the four IFC's in 1987, May 25 - June 7, June 24 - July 12, August 5 - 22, and October 3 - 17.

Temporal Coverage Map:

Not available.

Temporal Resolution:

Data are reported at 30 minute intervals and are available daily during the four IFC's.

Data Characteristics:

The SQL definition for this table is found in the SF_30MIN.TDF file found on the CD-ROM Volume 1. The following chart lists only those 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 100x100 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]
SOLAR_RADTN_DOWN The downward (incoming) solar radiation.	[Watts] [meter^-2]
SOLAR_RADTN_UP The upward (outgoing) solar radiation.	[Watts] [meter^-2]
SOIL_HEAT_FLUX_0_TO_5CM The soil heat flux recorded somewhere between 0 and 5 cm in depth. This is an average from 0 to 5 cm.	[Watts] [meter^-2]
HEAT_STORAGE The heat storage in the top soil layer.	[Watts] [meter^-2]
SOIL_TEMP_0_TO_25MM The soil temperature recorded somewhere between 0 and 25 mm in depth. Recorded at 25 mm.	[degrees Celsius]
SOIL_TEMP_5_TO_10CM The soil temperature recorded somewhere between 5 and 10 cm in depth. Recorded at 10 cm.	[degrees Celsius]
SOIL_TEMP_20_TO_50CM The soil temperature recorded somewhere between 20 and 50 cm in depth. Recorded at 50 cm.	[degrees Celsius]
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_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]
W_T_MEAN The mean of AIR_TEMP_MEAN x WIND_VELOC_VERT_MEAN in this 30 minutes.		[Watts] [meter^-2]
W_E_MEAN The mean of VAPOR_PRESS_MEAN x WIND_VELOC_VERT_MEAN in this 30 minutes.		[Watts] [meter^-2]
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		

```
the 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 which 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 were described here (i.e., reported by H.L. Weaver) contain data.

SITEGRID_ID	STATION_ID	OBS_DATE	OBS_TIME	LATENT_HEAT_FLUX
4609-ECW	22	17-AUG-87	1215	-11
4609-ECW	22	17-AUG-87	1245	-38
4609-ECW	22	17-AUG-87	1315	-92
4609-ECW	22	17-AUG-87	1345	-129

NET_RADTN	SENSIBLE_HEAT_FLUX	SOIL_HEAT_FLUX	DIFFUSE_SOLAR_RADTN_DOWN
-24	2	46	
28	-3	28	
96	-16	11	
168	-35	-5	

SOLAR_RADTN_DOWN	SOLAR_RADTN_UP	SOLAR_RADTN_NET	SOLAR_RADTN_DOWN_SDEV
999	999		
999	999		
999	999		
999	999		

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
--------------   -----------------------   ------------------------
41
33
23
13
SOIL_HEAT_FLUX_10_TO_20CM   HEAT_STORAGE   SOIL_WATER_POTNTL_0_TO_5CM
-------------------------   ------------   --------------------------
4
-5
-12
-17
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
-------------------   ---------------------   -------------------
21.83                                       22.97
21.92                                       22.84
22.14                                       22.76
22.45                                       22.76
SOIL_TEMP_10_TO_20CM   SOIL_TEMP_20_TO_50CM    RAINFALL    BOWEN_RATIO
--------------------   --------------------   ----------   -----------
23.59                           -9.99
23.56                           -9.99
23.53                           -9.99
23.47                             .27
WIND_SPEED    WIND_DIR    WIND_SPEED_MIN   WIND_SPEED_MAX   WIND_SPEED_SDEV
----------   ----------   --------------   --------------   ---------------
1.2         47
1.32        91
1.14        45
.7         1
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
-------------------   --------------------   -------------------
WIND_SPEED_LAT_SDEV   WIND_SPEED_VERT_SDEV   AIR_TEMP_LOW   AIR_TEMP_HIGH
-------------------   --------------------   ------------   -------------
.09
.11
.15
.15
AIR_TEMP_OTHER   AIR_TEMP_MEAN   AIR_TEMP_MEAN_SDEV   AIR_TEMP_OTHER_SDEV
--------------   -------------   ------------------   -------------------
18.69             .26
20.43             .2
21.78             .24
23.9              .37
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
----------------   ----------------   ----------------   -------------
1.58              .029
```

1.68	.058
1.77	.076
1.69	.08

REL_HUMID_HIGH	REL_HUMID_SDEV	SURF_AIR_PRESS	FRICTION_VELOC
.11			
.14			
.13			
.1			

W_T_MEAN	W_E_MEAN	CO2_CONTENT	OZONE_CONTENT	CO2_CONTENT_SDEV
-.002	.0006			
.003	.0021			
.014	.0051			
.024	.0056			

OZONE_CONTENT_SDEV	CO2_FLUX	OZONE_FLUX	FIFE_DATA_CRTFCN_CODE
CPI			
CPI			
CPI			
CPI			

LAST_REVISION_DATE
29-AUG-88
29-AUG-88
29-AUG-88
29-AUG-88

8. Data Organization:

Data Granularity:

These are point data. However, the eddy correlation data represents an area ranging from about 0.01 ha for very stable atmospheric conditions to about 1 ha for unstable and some neutral atmospheric conditions. Data are reported at 30-minute intervals and are available daily during the four IFC's.

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:

Pascal code from data processing program

SATURATED VAPOR PRESSURE: es

```
function es(T:real):real; {saturated vapor pressure in kPa}

var es_mb:real; {mb units}

begin

    es_mb := 6.1078 + T * (0.443652 + T * (0.014289 + T * (2.65065E-4 + T * (3.03124E-6 + T * (2.03408E-8 + 6.13682e-11 * T)))));

    es := es_mb / 10;

end;
```

SLOPE OF SATURATED VAPOR PRESSURE: s

```
function s(T:real):real; {slope of saturated vapor pressure in kPa/K}

var s_mb:real; {mb/K units}
```

begin

s_mb := 0.44381 + T * (0.028570 + T * (0.00079381 + T * (1.215215E-5 + T * (1.03656E-7 + T * (3.53242E-10 - 7.090245e-13 * T)))));

s : =s_mb / 10;

end

AIR DENSITY, Rho (kg/m^3)

Rho := 1.2929 * 273.13 / Tk * (P - 0.3783 * q * Tk / 2164) / 101.323;

Where:

P: air pressure (kPa)
q: vapor density (g/m^3)

HEAT CAPACITY OF AIR AT CONSTANT PRESSURE (J/kg)

Cp := (1004 + 1820.4 * M) / (1 + M);

M := 0.622 * q * Tk / 2164 / (P - q * Tk / 2164);

Where:
P: air pressure (kPa)
q: vapor density (g/m^3)

VAPOR PRESSURE FROM WET-BULB PSYCHROMETER:

e := es (Tw) - 0.063115 * (1 - 0.000946 * Tw) * (Td - Tw)

STANDARD DEVIATION OF VAPOR PRESSURE (kPa) FROM STANDARD DEVIATION OF VAPOR DENSITY (g/m^3)

Sige := SigQ * Tk / 2164;

STANDARD DEVIATION OF VAPOR PRESSURE (kPa) FROM STANDARD DEVIATION OF VAPOR DENSITY (g/m^3)

e := q / 2164 * Tk;

NET RADIATION:

Average 1 second samples from single net radiometer.

SOIL HEAT FLUX:

Average 1 second samples from three plates.

UPPER LAYER HEAT STORAGE:

Average 10 minute samples from three Delta-T/delta-t measurements.

HEAT CAPACITY:

C(s) = rho(s) (0.785 + 4.18 RWC)

Where:

C(s) = heat capacity
rho(s) = dry soil density
RWC = gravimetric fractional soil moisture

BETA:

Sensible heat flux/Latent heat flux [dimensionless]

Data Processing Sequence:

Processing Steps:

1. Read data array from data logger file.
2. Instruments off? If so enter null data values.
3. Data within range? If not enter null data values.
4. Enter backup vapor pressure observations (Assman psychrometer).
5. Read instrument calibration table.
6. Calculate heat storage in soil surface layer.
7. Calculate fluxes and friction velocity.
8. Replace standard deviation of air temperature and humidity from fast psychrometer with those from eddy correlation instruments, when available.

Processing Changes:

None.

Calculations:

SENSIBLE HEAT FLUX, H

H := -Rho * Cp * wT

Where:

wT: covariance of vertical velocity (**w**) and air temperature (**T**) real-time calculation by data logger (Tanner and Greene, 1988)

LATENT HEAT FLUX, L

L := -LAMBDA * wq;
LAMBDA = 2501.3-2.366 * T { J/g }
wq := wVq / VqBar / (A + 2 * B * q)

Where:

wVq: covariance of vertical velocity (**w**) and hygrometer output voltage (**Vq**), real-time calculation by data logger (Tanner and Greene, 1988)
VqBar: mean hygrometer output voltage (**Vq**), real-time calculation by data logger (Tanner and Greene, 1988)
A, B: hygrometer calibration constants
q: vapor density (g/m^3)
T: air temperature { C }
we := Tk / 2164 * wq; (vapor pressure flux, kPa m/s)

FRICTION VELOCITY, ustar { m/s }

if wT > 0

then **ustar := (k * u + power (1.6 * k * g * z * wt / Tk,0.33)) / ln(z / zo)**

else **ustar := k * u / ln(z / zo) / (1 - 5 * sqr (ln(z / zo)) * g * z * Wt / k / u^3 / Tk);**

zL := -k * g * z * (wT + 0.15 * wq) / power(ustar,3) / Tk;

{iterate once to improve accuracy of estimate}

if wT>0

then **ustar := k * u / (ln(z / zo) - power(-2 * zL,0.33))**

else **ustar := k * u / (ln(z / zo) + 5 * zL);**

if ustar < 0.05 then ustar := 0.05;

(* **k:** von Karman's constant: 0.4
g: gravitational constant: 9.8 m/s^2
u: windspeed at height z, { m/s }
z: anemometer height, { m }
zo: roughness length: ~0.03 m *)

Special Corrections/Adjustments:

WATER VAPOR FLUX CORRECTION FOR AIR DENSITY CHANGES AT SURFACE (Webb et al., 1980)

wq(adjusted) = wq + q / Tk * Wt

Where:

Tk: air temperature { K }

q: vapor density (g/m^3)

Calculated Variables:

- Saturated Vapor Pressure,
- Slope Of Saturated Vapor Pressure,
- Air Density,
- Heat Capacity Of Air At Constant Pressure,
- Vapor Pressure From Wet-Bulb Psychrometer,
- Standard Deviation Of Vapor Pressure,
- Net Radiation
- Soil Heat Flux,
- Heat Capacity,
- Sensible Heat Flux,
- Latent Heat Flux,
- Friction Velocity, and
- Water Vapor Flux Correction For Air Density Changes At Surface.

Graphs and Plots:

None.

10. Errors:

Sources of Error:

During Aug. 5-12, 1987, all thermocouple measurements at Site 28 (sitegrid 6943-ECW) required some adjustment because a voltage offset in the data logger affected single-ended measurement of millivolt-range signals. The correction for this voltage offset was determined mainly at night from the non-zero values of pyranometers. Large daytime changes in the voltage offset could be closely estimated from changes in the soil temperature signal at 50 cm. Small daytime changes in the voltage offset went undetected, resulting in inaccuracies in the temperature measurements reported from Site 28 during this 8-day period. The data so affected are: SOIL_TEMP_0_TO_25MM, SOIL_TEMP_5_TO_10CM, SOIL_TEMP_20_TO_50CM, AIR_TEMP_MEAN, and VAPOR_PRESS_MEAN.

Quality Assessment:

It was recognized early in the study that standardization of "constants" (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:

Spot checks of raw data was scanned in data-logger memory and hand recorded in field notes several times each day during field work with only occasional exceptions. Data values were qualitatively assessed for accuracy against previous data from site and from other USGS surface flux sites.

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.

Additional Quality Assessments:

Graphical ("strip chart") display of selected data and data combinations for all the periods submitted to this database.

The data scanned for reasonable diurnal behavior were:

```
SOIL_HEAT_FLUX          NET_RADTN               LATENT_HEAT_FLUX
SENSIBLE_HEAT_FLUX      SOIL_TEMP_0_TO_25MM     SOIL_TEMP_5_TO_10CM
AIR_TEMP_MEAN           VAPOR_PRESS_MEAN
```

Meaningful data combinations that helped ferret out bad data were used. One of these "evaporativity", **E** is calculated:

> **E = LATENT_HEAT_FLUX / (LATENT_HEAT_FLUX + SENSIBLE_HEAT_FLUX)**

Another data combination was "surface resistance", **Rc**, from the Penman-Montieth combination equation (Montieth, 1973):

Rc = Ra {[s / gamma(R_NET - SOIL_HEAT_FLUX) + lambda (es - VAPOR_PRESSURE_MEAN) / Ra] / LATENT_HEAT_FLUX Ra s / gamma - 1}

where:

Ra = ln[(z - d) / z0] / FRICTION_VEL / k
z: instrument height
d: displacement height of vegetation
k: vonKarman's constant (=0.4)
s: slope of saturation vapor pressure - temperature curve (see the *Formulae Section*)
es: saturation vapor pressure
gamma: psychrometric constant
lambda: latent heat of vaporization (= 2501.3-2.366 * T { J/g })

When time series graphs of the data or **E** or **Rc** appeared unreasonable, the offending data items were identified and corrected or replaced by either interpolation or by substitution from backup data measurements. If neither of these was possible, the null value was submitted instead of the data values.

Several of the key surface flux parameters have undergone extensive intercomparison and examination for spikes in the data. Details of these analyses are described in the Surface Flux Baseline 1992 document on FIFE CD-ROM Volume 1.

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:

or errors in the data have been reported:

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:

Not available.

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 (USGS) data are available on FIFE CD-ROM Volume 1. The CD-ROM filename is as follows:

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

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 .ECW for this data set.

17. References:

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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.

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:

CD-ROM Compact Disk (optical), Read-Only Memory CSI Campbell Scientific Inc. DAAC Distributive Active Archive Center EOSDIS Earth Observation System Data and Information System 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 URL Uniform Resource Locator USGS United States Geological Survey UTM Universal Transverse Mercator

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 as archived on the FIFE CD-ROM series.

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Document Curator:

DAAC Staff

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