Eddy Corr. Surface Flux: GSFC (FIFE)

Summary:

The Eddy Correlations Surface Flux Observations (GSFC) Data Set contains surface flux measurements made at selected sites within the FIFE study area. The surface flux and micrometeorological measurements in this data set were collected from a single location located in the southwest quadrant on a upland, grazed area. The data set contains data collected daily from June 26 - October 17, 1987 during the three Intensive Field Campaigns. No data is available between the campaigns.

Micrometeorological techniques of eddy correlation and Bowen ratio were used in determining the fluxes of sensible heat, latent heat, and carbon dioxide in FIFE. 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 of sensible and latent heat are computed as covariances of the fluctuations of vertical wind velocity with fluctuations of temperature and vapor density at the same point and time.

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1. Data Set Overview:

Data Set Identification:

Eddy Corr. Surface Flux: GSFC (FIFE)
(Eddy Correlations Surface Flux Observations (GSFC)).

Data Set Introduction:

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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, black body temperature, heat storage, soil temperature.

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 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 surface flux and micrometeorological measurements available in this data set were collected from a single location within the FIFE study area. This site (station 30, SITEGRID_ID = 4268-ECG) is located in the southwest quadrant on a upland, grazed area.

The overall time range for this data set is from June 26 - October 17, 1987. During this period, data are available daily during the three Intensive Field Campaigns. No data is available between the campaigns.

Micrometeorological techniques of eddy correlation and Bowen ratio were used in determining the fluxes of sensible heat, latent heat, and carbon dioxide in FIFE.

Related Data Sets:

- Eddy Correlation Surface Flux Observation (USGS).
- Eddy Correlation Surface Flux Observation (UNL).

- 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. Robert J. Gurney
University of Reading

Title of Investigation:

Surface Flux Measurements By Eddy Correlation Technique During FIFE.

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Newark, DE
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Requested Form of Acknowledgment.

The Eddy Correlation Surface Flux Observations (GSFC) were obtained and prepared by Richard T. Field, University of Delaware. 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 of sensible and latent heat are computed as covariances of the fluctuations of vertical wind velocity with fluctuations of temperature and vapor density at the same point and time.

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 collocated 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%.

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.

The krypton hygrometer used at site 30 (4268-ECG) was mounted 60 cm cross wind from the sonic anemometer to minimize aerodynamic interference. It later appeared that this separation introduced a loss of covariance of up to one half the vapor flux signal. The lost signal was not adequately recovered using the correction for spectral loss derived by Moore (1986). Consequently, the latent heat flux was estimated from the eddy correlation sensible heat flux and fluctuations of water vapor and air temperature according to a method similar to those described in Wesley (1988) (see the *Formulae Section*).

4. Equipment:

Sensor/Instrument Description:

Summary of Eddy Correlation System used by GSFC/Univ. of Delaware:

- Net radiation sensor: Thornthwaite MNR 601
- Soil heat flux sensor: Thornthwaite 610 soil heat flowdisks (2 averaged at 5 cm)
- Upper layer heat storage sensor: Single-probe thermocouple (2 averaged at 2.5 cm)
- Vertical wind velocity sensor (path length): CSI sonic (10 cm)
- Air Temperature sensor (response time): CSI 12-um Thermocouples (0.01 s)
- Moisture sensor (response time): CSI krypton KH-20 (0.01 s)
- Sensor height above canopy (above ground): 1.75 m (1.85 m)
- Eddy Correlation Sampling rate: 13 Hz
- Duty cycle for 30 min averaging period: 100%

Eddy correlation measurements at site 30 (4268-ECG) used a single-axis Campbell Scientific instruments (CSI) sonic anemometer with fine-wire thermocouple model CA27T S/N 1198 for vertical wind speed (w) and air temperature (T) fluctuations.

Water vapor density fluctuations were observed with a Campbell Scientific Instrument krypton absorption hygrometer model KH20 S/N 1022.

Raw fast-response eddy fluctuation data were sampled at a rate of 13 per second and processed in real-time to obtain half-hour average variances and covariances.

Ground heat flux observations used two heat flux plates at a depth of 5 cm in the soil and three thermocouples at a depth of 2.5 cm with which the change in heat storage in the 0-5 cm layer was calculated.

Soil heat flux plates C. W. Thornthwaite Associates model 610 S/N CR4 and CR5.

Net radiation was observed with one C. W. Thornthwaite Associates net radiometer model 601 MNR S/N 511. MNR S/N 500 used for on site net radiation survey.

Solar radiation, downwelling and upwelling, was observed with two Eppley Laboratories model 8-48 black and white pyranometers S/N 10606 and 10607 respectively.

Surface brightness temperature was observed with one Everest radiation thermometer model 112C S/N 866.

Data logging was done using 3 Campbell Scientific 21x loggers.

Collection Environment:

Ground-based.

Source/Platform:

Ground observations.

Source/Platform Mission Objectives:

To measure fluxes of sensible and latent heat using the Eddy correlation technique, the radiation balance, and ground heat flux. Sampling, recording, and near real-time processing of the data were done with computer based data loggers.

Key Variables:

Latent heat flux, net radiation, sensible heat flux, soil heat flux, incoming solar radiation, reflected solar radiation, surface brightness temperature, soil temperature.

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. A prototype version of this instrument is described by Campbell and Unsworth (1979).

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 krypt on 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 instrument enclosure was defined by a single strand electric fence about 1 m high measuring about 22 x 22 m. It contained all instruments for collocated sites 30 (4268-ECG) and 32 (4268-BRK). Vegetation height within the enclosure was about 0.1 m. For site 30 (4268-ECG), the eddy correlation instruments were located 1.85 m above the ground. The eddy correlation instrument set was moved to the upwind side of the instrument enclosure as the wind changed direction to avoid instrument obstacles to the air flow.

Net radiation and down welling solar radiation were observed 1.3 m above the soil surface, about 1.2 m above the canopy. Upwelling solar radiation was measured 1.1 m above the soil surface. The radiation thermometer was mounted 1.0 m above the surface and had a view angle of 45 degrees. The radiation instruments were located in the western central section of the enclosure. A mast carrying an R M Young Wind Sentry anemometer at 2.7 m height was located in the center of the enclosure. A 2 m mast to observe wind velocity and temperature profiles was located in the south west corner of the enclosure. Instruments for Bowen ratio observations designated as site 32 (4268-BRK) were located in the southeast corner of the enclosure.

Manufacturer of Sensor/Instrument:

Sonic anemometer:

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

Fine-wire thermocouple:

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

Krypton hygrometer:

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

Soil heat transducer:

C W Thornthwaite Associates
Route 1
Elmer, NJ 08318.

Radiation Thermometer:

Everest Interscience Inc.
P.O. Box 3640
Fullerton CA 92634.

Pyranometer:

Eppley Laboratories, Inc.
Newport, RI 02840.

Net Radiometer:

C W Thornthwaite Associates
Route 1
Elmer NJ 08318.

Data logging system:

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

Calibration:

A net radiometer calibration was accomplished using a transfer pyheliometer standard on loan from the Solar Energy Research Institute. See Field et al. 1992 for discussion of substantial differences noted between calibrated net radiometers of different design and the subsequent adjustments applied to all net radiometers.

Specifications:

Calibration factors.

- The net radiometer was calibrated by the sun/shading technique and compared over the succeeding 24-hour period using data collected every 5 minutes (see Field et al. 1992). CWTA S/N 511 182.2 [W][m^-2][mV^-1] CWTA S/N 500 269.0 [W][m^-2][mV^-1].
- Pyranometer: S/N 10606 calibrated by KSU (see Field et al. in press) S/N 10606 87.78 [W][m^-2][mV^-1], S/N 10607 86.18 [W][m^-2][mV^-1].
- Sonic anemometer: supplied by manufacturer. 1.0 [m][s^-1][V^-1] with sonic pathlength 0.1 m. Comparison prior to IFC 4 with Campbell Scientific sonic anemometer system S/N 1112 owned by the University of Delaware showed no systematic difference and agreement within 4% for the wind and temperature fluctuation statistics observed by the instruments.
- Krypton hygrometer: supplied by manufacturer. 0.150 [m^3][g^-1], optical pathlength 0.907 cm. Comparison with Campbell Scientific krypton hygrometer S/N 1034 owned by U. S. Geological Survey on 17 April 1988 showed no systematic difference between the two instruments.
- Pyranometer: calibration value obtained by KSU used in FIFE for S/N 10606 87.78 [W][m^-2][mV^-1]. The factory value of 92.45 [W][m^-2][mV^-1] dates from 1970.

  Calibration factor used in FIFE for S/N 10607 obtained by comparison with re-calibrated S/N 10606 was 86.18 [W][m^-2][mV^-1].

- Soil heat transducer: diameter 2.5 cm, thickness 3 mm. Re-calibrated in 1987 by Dr. L. Fritschen, Univ. of Washington to obtain calibration factors used in FIFE: S/N CR-4 245.5 [W][m^-2][mV^-1];

  S/N 269.0 [W][m^-2][mV^-1].

- Radiation thermometer: calibration supplied by manufacturer. 1 K / mv Instrument calibration checked after IFC 2 against a Barnes PRT-5 infrared thermometer owned by the University of Delaware looking at a water surface. The two showed agreement within 0.25 K. Checked against black body after IFC 4.

Tolerance:

Precision estimates:

- Solar and net radiation: 1 [W][m^-2].
- Air temperature fluctuations: 0.1 [K].
- Vertical wind velocity fluctuations: 0.01 [m][s^-1].
- Water vapor density fluctuations: varies with vapor density. Assuming a resolvable signal level of 0.01 mV above noise-about 0.005 [g][m^-3] at ambient vapor density 19 g m^-3 and 0.0002 [g][m^-3] at ambient vapor density 4 [g][m^-3]. Equivalent vapor pressure at 300 [K] are 0.0007 [kPa] at 2.6 [kPa] ambient vapor pressure and 0.00003 at 0.55 [kPa] ambient vapor pressure.
- Surface brightness temperature; 0.1 [K].

Frequency of Calibration:

Radiometers:

One calibration of net radiometers by KSU and FIFE surface flux group summer 1987. Comparison with local laboratory standard during summer 1988 showed no change.

Other Calibration Information:

None.

5. Data Acquisition Methods:

The data were acquired by the sensors; the system is designed to retrieve all major components of the surface radiation and energy budget. All observations were sampled at 1 second intervals, converted to scientific units and averaged over 15 minutes before storage except for the eddy correlation values which were sampled 13 times per second and averaged over 15 minutes. Fifteen minute values were later averaged for reporting one-half hour averages.

6. Observations:

Data Notes:

Not available.

Field Notes:

Energy fluxes towards the soil surface are positive while fluxes away are negative. All fluxes are in [W][m^-2], temperatures in degrees Celsius, vapor density in [g][m^-3]. Soil heat flow plates are buried at 5 cm and the soil temperature probes at 2.5 cm. Therefore the soil heat storage term is estimated for the upper 5 cm of soil.

Site 30/32 (4268-ECG)/(4268-BRK) is located on the south end of a ridge which tends to the northeast. Land slopes downward away from the instrument enclosure at a grade between 1.5% and 4.7% except to the northeast where the slope is about 0. These grades are measured over 90 m traverse beginning at the instrument fence. For azimuth between about 120 and 180 the slope is least and provides the best fetch for eddy correlation observations of surface fluxes. Between 195 and 225 there is a gully which produces a slope of almost 5%. To the southwest the slope is about 3%; to the northwest it exceeds 4%. Beyond 90 m upwind in all directions, except to the northeast, grades get steeper to approach 10%. The fetch to the north was obstructed by a 1 m by 2 m wooden site marker. The wind instrumentation was positioned for unobstructed observation of southerly winds. The eddy correlation equipment was moved as wind direction changed to the upwind side of the instrument enclosure.

On several occasions during IFC 2, especially around midday on 10 and 11 July and around 1600 on 5 July grazing cattle were observed to move upwind of the eddy correlation and Bowen ratio instruments and may have disturbed the fetch. The animals were driven away several times during these three days.

Note that while an effort was made during IFC 2, 3 and 4 to keep surface conditions within the instrument enclosure similar to conditions outside the enclosure, visual observations from the helicopter suggested that during IFC 2 and 3 at least, the canopy outside was thinner and surface temperatures were higher.

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 location within the FIFE study area:

SITEGRID	STN	LATITUDE	LONGITUDE	NORTHING	EASTING	ELEV	SLOPE	ASPECT
4268-ECG	30	39 03 15	-96 28 27	4325626	718574	445		

Site 30 (4268-ECG) is located in the northeast quadrant of the FIFE area along the boundary with the southeast quadrant.

Spatial Coverage Map:

Not available.

Spatial Resolution:

These are point data except that eddy flux data apply to an upwind surface "footprint" (see Leclerc and Thurtell 1989 and Schmid and Oke 1990). In this case the fluxes apply to the surface between about 20 to 160 m upwind. Radiation and ground heat flux observations are made within the instrument enclosure.

Effort was made to keep the ungrazed grass within the enclosure about the same height as the grazed grass outside the enclosure by cutting the grass during IFC 2 and just prior to IFC 3.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

Surface flux data at site 30 (4268-ECG) were collected during IFC 2 (25 June-11 July), IFC 3 (6-21 August 1987) and IFC 4 (5-16 October), 1987. During this period there were 47 days of data.

Temporal Coverage Map:

Not available.

Temporal Resolution:

The reported data values are 30 minute averages with reporting intervals centered on the quarter and three quarter hour. During the three IFCs the measurements were made 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 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 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]	

SOLAR_RADTN_DOWN The downward (incoming) solar radiation.	[Watts] [meter^-2]
SOLAR_RADTN_UP The upward (outgoing) solar radiation.	[Watts] [meter^-2]
BB_TEMP_LONGWAVE_UP The black body temperature for LONGWAVE_RADTN_UP.	[degrees Kelvin]
SOIL_HEAT_FLUX_0_TO_5CM The soil heat flux recorded somewhere between 0 and 5 cm in depth. Recorded as 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_10_TO_20CM The soil temperature recorded somewhere between 10 and 20 cm in depth. Recorded at 15 cm.	[degrees Celsius]
WIND_SPEED_VERT_SDEV The standard deviation for the vertical wind speed.	[meters] [sec^-1]
AIR_TEMP_MEAN_SDEV The standard deviation for the mean air temperature.	[degrees Celsius]
VAPOR_PRESS_SDEV The standard deviation for the vapor pressure.	[kiloPascals]
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:

* 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.

** 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.

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 R.T. Field) contain data.

SITEGRID_ID	STATION_ID	OBS_DATE	OBS_TIME	LATENT_HEAT_FLUX
4268-ECG	30	17-AUG-87	15	-102
4268-ECG	30	17-AUG-87	45	-69
4268-ECG	30	17-AUG-87	115	-42
4268-ECG	30	17-AUG-87	145	-21

NET_RADTN	SENSIBLE_HEAT_FLUX	SOIL_HEAT_FLUX	DIFFUSE_SOLAR_RADTN_DOWN
9	22	12	
-49	36	30	
-64	34	45	
-59	22	49	

SOLAR_RADTN_DOWN	SOLAR_RADTN_UP	SOLAR_RADTN_NET	SOLAR_RADTN_DOWN_SDEV
159	49		
72	26		
17	4		

0 0

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

-1000
-1000
-1000
-1000

TOTAL_RADTN_UP SOIL_HEAT_FLUX_0_TO_5CM SOIL_HEAT_FLUX_5_TO_10CM

-9
3
13
22

SOIL_HEAT_FLUX_10_TO_20CM HEAT_STORAGE SOIL_WATER_POTNTL_0_TO_5CM

21
27
32
28

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

28.55
28.04
27.43
26.9

SOIL_TEMP_10_TO_20CM SOIL_TEMP_20_TO_50CM RAINFALL BOWEN_RATIO

27.74
27.72
27.66
27.59

WIND_SPEED WIND_DIR WIND_SPEED_MIN WIND_SPEED_MAX WIND_SPEED_SDEV

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

.35
.32
.27
.14

AIR_TEMP_OTHER AIR_TEMP_MEAN AIR_TEMP_MEAN_SDEV AIR_TEMP_OTHER_SDEV

.23
.35
.41
.49

```
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
----------------   ----------------   ----------------   -------------
.07
.043
.033
.032
REL_HUMID_HIGH   REL_HUMID_SDEV   SURF_AIR_PRESS   FRICTION_VELOC
--------------   --------------   --------------   --------------
 W_T_MEAN     W_E_MEAN    CO2_CONTENT   OZONE_CONTENT   CO2_CONTENT_SDEV
----------   ----------   -----------   -------------   ----------------
OZONE_CONTENT_SDEV    CO2_FLUX   OZONE_FLUX    FIFE_DATA_CRTFCN_CODE
------------------   ----------   ----------   ---------------------
CPI
CPI
CPI
CPI
LAST_REVISION_DATE
------------------
12-MAY-93
12-MAY-93
12-MAY-93
12-MAY-93
```

8. Data Organization:

Data Granularity:

These are point data except that eddy flux data apply to an upwind surface "footprint" (see Leclerc and Thurtell 1989 and Schmid and Oke 1990). The reported data values are 30 minute averages with reporting intervals centered on the quarter and three quarter hour. During the three IFCs the measurements were made 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:

Ground heat flux:

G(t) = G1(t) + S(t)

S(t) = C delT(t) 0.05[m] / 1800[s]

C = rhob (0.46(qm / rhom) + 0.6 (qo / rhoo) + qw) 4180 [J][cal^-1]

where:

G(t) = ground heat flux at the soil surface at time **t** integrated over ½ hour time interval **delt**
G1(t) = soil heat flux at 5.0 cm depth averaged between two soil heat flux plates over **delt**
S(t) = change in heat stored in the soil between the surface and 5 cm depth during the time interval **delt**.
C = volumetric heat capacity of the soil [J][m^-3][K^-1] according to de Vries (1975)
delT(t) = change in soil temperature over time **delt**
rhob = bulk density of the soil (1036 [kg][m^-3])
rhom = density of the soil mineral constituents (2.65 [g][cm^-3]
rhoo = density of the soil organic constituent (1.3 [g][cm^-3])
qm = weight fraction of mineral matter in the soil (0.95)
qo = weight fraction of organic matter in the soil (0.05)
qw = weight fraction of water in the soil (variable)

The weight fraction of water, **qw**, was obtained from bulk soil samples obtained by FIFE staff once per day at site 30/32 (4268-ECG)/(4268-BRK) generally between the hours of 1000 and

1300 during the IFC. At site 30 (4268-ECG) only the soil sample taken within the enclosure was used to compute C. At site 32 (4268-BRK) all 5 samples were used.

Sensible Heat Flux:

Hec = rhoa cp (<wT - <w <T)

where:

rhoa is the air density,
cp is the air specific heat at constant pressure,
<Wt is the average product of vertical velocity and air temperature fluctuations over the averaging period,
<w is the average vertical fluctuations velocity during the period
<T is the average of the air temperature fluctuations during the sample period.

Vapor density fluctuations are obtained from the krypton absorption hygrometer according to the following:

rhov = V' / (V X Kw)

where:

rhov is the fluctuation value of water vapor density [g][cm^-3]
V' is the instantaneous value of the hygrometer output [mv]
V is the average output of the hygrometer during the fifteen minute averaging period [mv]
X is the pathlength of the hygrometer (0.907 [cm])
Kw is the instrument water vapor absorption coefficient [m^3][g^-1][cm^-1].

Latent heat flux:

LE = | Hec | A (sigrhov / sigT) sign(LEec)

where:

| Hec | is the absolute value of the eddy correlation observation of sensible heat flux
sign (LEec) is the sign of the eddy correlation observation of latent heat flux
sigrhov is the standard deviation of the water vapor fluctuations
sigT is the standard deviation of the temperature fluctuations
A is the ratio of the latent heat of vaporization to the product of air density and specific heat at constant pressure.

Vapor pressure is obtained from vapor density for reporting the standard deviation of the vapor pressure fluctuations (VAPOR_PRESS_STDEV) according to the following equation:

e = rhov Ta / (2.17 x 10^3)

where:

e is vapor pressure [kPa]
rhov is vapor pressure density [g][m^-3]
Ta is air temperature, (Ta2 from station 32 (4268-BRK)) [K]

Data Processing Sequence:

Processing Steps:

Conversion of sensor signals to scientific units accomplished during data logging process. Subsequent corrections were made to net radiation of about 2% in accordance with Field et al. (1992) and to the eddy fluctuations observations to compensate for spectral loss as noted under the *Calculations Section*.

Processing Changes:

None.

Calculations:

Special Corrections/Adjustments:

Eddy fluctuations:

> Corrections to compensate for finite sensor response time constants, spatial averaging, and sensor separation according to Moore (1986) were applied to the covariance and variance observations.

Net radiation:

> Observations have been adjusted in accordance with Field et al. (1992), with the following equation:
>
> **Y = Bo + B1 * (instrument indication)**
>
> where:
>
> **Bo** = 1.674 for positive values and 3.295 for negative values [W][m^-2]
> **B1** = 0.9827 for positive values and 1.0437 for negative values

Calculated Variables:

- Ground heat flux,
- Sensible Heat Flux,
- Latent heat flux,
- Vapor density fluctuations, and
- Vapor pressure.

Graphs and Plots:

None.

10. Errors:

Sources of Error:

The site was not ideal for eddy correlation flux observations because of the sloping terrain. Further, because during IFC-2 the site was rather intensively grazed by cattle, the vegetation inside and outside the instrument enclosure was not really the same. It is possible, especially during IFC 2 and 3, that surface temperature outside the enclosure is greater than inside and that net radiation and albedo during daytime outside and inside the enclosure are different.

Latent heat flux was computed in an experimental manner. Values may be 10 to 20% low. Observations are unreliable during the morning and evening intervals when sensible heat flux reverses sign.

Net radiation was observed on two different types of net radiometers at site 30 (4268-ECG) and site 32 (4268-BRK) within the instrument enclosure. The site 30 (4268-ECG) instrument was a CWTA thin window type. The site 32 (4268-BRK) instrument was REBS thick window double dome type. Values given by the two instruments at any given time should be the same, but were not. The actual uniformity of net radiation at site 30 (4268-ECG) and 32 (4268-BRK) was established during IFC 3 by using MNR S/N 500 as a rover to compare with the site 30 (4268-ECG) station instrument, MNR S/N 511. These comparisons showed that any differences between site 30 (4268-ECG) and site 32 (4268-BRK) reported net radiation values must be of instrumental origin.

Net radiation observations from all net radiometers have been adjusted to improve agreement between thin window and thick window, double dome, net radiation instruments. Observations made with thin window instruments such as the radiometer used at site 30 (4268-ECG) were changed very little by this adjustment, but systematic differences between radiometers due to design differences remain in these data (see Field et al. 1992).

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. See Field et al. (1992) and Nie et al. (1992).

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. These observations are consistent with other stations. Soil heat flux observations at stations 30 (4268-ECG) and 32 (4268-BRK) are noticeably higher than the average of all stations, probably because of the sparse vegetation canopy at this location.

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], which ever is larger
- Sensible heat flux +/- 15 to 20 % or +/-30 [W][m^-2], which ever 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:

Comparisons with observations at similar stations:

Incident solar radiation compared with station 38 on clear days shows excellent agreement.

Comparing station 30 against collocated station 32 (4268-BRK) when net radiation at station 32 (4268-BRK) is adjusted according to the disaggregation correction described in Field et al. (1992) shows sensible heat flux at station 30 in close agreement with station 32 (4268-BRK) for IFC 2 and 3 and about 15% lower during IFC 4. Latent heat flux at station 30 is about 15% lower than according to station 32 (4268-BRK) during IFC 2 and 3 about 20% higher during IFC 4. There is, of course, considerable scatter of the individual observations.

Sensible heat flux by eddy correlation regressed against that observed at station 26 by eddy correlation shows good agreement. During IFC 2 (when site 30 was being heavily grazed, H was about 15% higher at site 30. During IFC 3 H was the same, within 10%, at the two sites. During IFC 4 H averaged about 15% higher at site 26.

Latent heat flux by eddy correlation regressed against that observed at station 26 shows station 30 values to be 10 to 15% lower than values at station 26 during IFC 2 and 3. Values during IFC 4 are very low at both stations and in good agreement.

Energy budget residuals for ½ hours were computed according to the following equation:

Residual = Rn - H - LE - G

where:

Rn is net radiation
H is sensible heat flux

LE is latent heat flux
G is ground heat flux

These energy budget residuals showed the average residuals during IFC 2, 3, and 4 to be about 25 +/- 50, 0 +/- 50, and -15 +/- 15 [W][m^-2] respectively. Individual daytime residuals were seldom larger than 100 and generally smaller than 50 [W][m^-2].

Several of the key surface flux parameters have undergone extensive intercomparisons and examinations 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:

The latent heat flux estimates are not valid near sunrise and sunset when the sensible heat flux changes sign, (see the *Additional Quality Assessment Applied Section*. Also see the *Usage Guidance Section* below).

Different missing values are used within each column. They can be positive or negative 9.9, 9.99, 99.99, 999.99, 9999 or 99999.99.

The missing indicators in the following fields may have been inadvertently converted to 1000. Use 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

Users may place requests by telephone, electronic mail, or FAX. Data is also available via the World Wide Web at

\DATA\SUR_FLUX\30_MIN\GRIDxxxx\YyyMmm\gridyddd.ECG or
\DATA\SUR_FLUX\30_MIN\GRIDxxxx\Yyyyy\ydddgrid.ECG

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 .ECG for this data set.

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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 CSI Campbell scientific Instruments DAAC Distributive Active Archive Center EOSDIS Earth Observation System Data and Information System FIFE First ISLSCP Field Experiment FIS FIFE Information System GSFC Goddard Space Flight Center ISLSCP International Satellite Land Surface Climatology Project LAI Leaf area index ORNL Oak Ridge National Laboratory PAMS Portable Automatic Mesonet REBS Radiation and Energy Balance Systems URL Uniform Resource Locator 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 archived on the FIFE CD-ROM series.

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