# Bowen Ratio Surface Flux: KSU (FIFE)

## Summary:

The Bowen Ratio Surface Flux Observations (KSU) Data Set contains surface flux measurements made at selected sites within the FIFE area. The sites were equipped with Bowen ratio equipment that was operated by several different groups. Each surface flux station was capable of measuring the fluxes of net radiation, latent heat and sensible heat. The Bowen ratio stations measured the soil heat flux as well. The components of the energy balance were determined with the Bowen Ratio Energy Balance (BREB) method. The BREB is a combination of the transport and the energy balance equations.

The surface flux and micrometeorological measurements available in this data set were collected from 23 locations with 27 site identifiers from 1987 through 1989. Thirteen of these locations were instrumented with stationary bowen ratio systems which collected daily measurements for months. These systems were all located in the northwest quadrant of the FIFE study area within the Konza Prairie Natural Research Area. Ten locations were instrumented in 1987 for a few days at a time with a portable Bowen ratio system. This roving system visited all but the southeast quadrant of the FIFE study area.

## Table of Contents:



## 1. Data Set Overview:

## Data Set Identification:

Bowen Ratio Surface Flux: KSU (FIFE).
(Bowen Ratio Surface Flux Observations (KSU)).

## Data Set Introduction:

The Bowen Ratio Surface Flux Observations (KSU) Data Set contains the fluxes of net radiation, latent heat and sensible heat measured at selected sites within the FIFE area. The Bowen ratio stations measured the soil heat flux as well.

## 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 diffuse solar radiation, incoming solar radiation, outgoing solar radiation, soil temperature, rainfall, Bowen ratio, wind speed, wind direction, air temperature, vapor pressure.

## Discussion:

Surface flux measurements were made at selected sites within the FIFE area. The major data collection effort was conducted in 1987 when 16 stationary sites were equipped with Bowen ratio equipment that was operated by several different groups. In 1988 and 1989, Bowen ratio surface flux stations were installed at 12 and 19 locations, respectively. Each surface flux station was capable of measuring the fluxes of net radiation, latent heat and sensible heat. The Bowen ratio stations measured the soil heat flux as well.

The surface flux and micrometeorological measurements available in this data set were collected from 23 locations with 27 site identifiers from 1987 through 1989. Thirteen of these locations were instrumented with stationary bowen ratio systems which collected daily measurements for months. These systems were all located in the northwest quadrant of the FIFE study area within the Konza Prairie Natural Research Area. Ten locations were instrumented in 1987 for a few days at a time with a portable Bowen ratio system. This roving system visited all but the southeast quadrant of the FIFE study area.

## Related Data Sets:

- Eddy Correlation Surface Flux Observations (USGS).
- Eddy Correlation Surface Flux Observations (UNL).
- Eddy Correlation Surface Flux Observations (GSFC).
- Eddy Correlation Surface Flux Observations (UK).

- Eddy Correlation Surface Flux Observations (Argonne).
- Bowen Ratio Surface Flux Observations (GSFC).
- Bowen Ratio Surface Flux Observations (Fritschen).
- Bowen Ratio Surface Flux Observations (Smith).
- Bowen Ratio Surface Flux Observations (UNL).
- Bowen Ratio Surface Flux Observations (USGS).

### FIS Data Base Table Name:

SURFACE_FLUX_30MIN_DATA.

# 2. Investigator(s):

### Investigator(s) Name and Title:

Dr. Ghassem Asrar (formerly at KSU)
NASA Headquarters

Dr. Ed Kanemasu (formerly at KSU)
Dept. of Agronomy University of Georgia

### Title of Investigation:

Assessing the effects of annual burning and topography on the surface energy exchanges.

### Contact Information:

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University of Georgia
Griffin, GA
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### Requested Form of Acknowledgment.

The Bowen Ratio Surface Flux Observations (KSU) obtained by Kansas State University were collected under the direction of Drs. G. Asrar and E. Kanemasu. The contribution of these data is appreciated.

# 3. Theory of Measurements:

The components of the energy balance were determined with the Bowen Ratio Energy Balance (BREB) method. The BREB is a combination of the transport and the energy balance equations. The Bowen ratio, **B** {a ratio of the transport or gradient equations of sensible heat, **H** and latent heat, **E**} is given by:

**B = H / E. (1).**

Where:

**H = -rho.c(p).K(h). dT/dz**

**E = -(rho.epsilon / P) l(v).K(v). de/dz**

where symbols are defined as:

**e** = Air vapor pressure
**epsilon** = Ratio of the molecular weights of wet and dry air
**c(p)** = Specific heat of air
**K(h)** = Eddy diffusivity for heat
**K(v)** = Eddy diffusivity fro water vapor
**p** = Atmospheric pressure
**rho** = Air density
**T** = Air temperature
**z** = Height or depth
**l(v)** = Latent heat of vaporization

Substituting (1) in the energy balance equation (2) yields the BREB (3). **Q** is net radiation and **G** is soil heat flux density.

**Q + G + H + E = 0 (2).**

In this system surface-air interface is considered as a closed system. Any energy flux coming in is considered positive and going out is negative.

**E = -(Q + G) / (1 + B) (3).**

# 4. Equipment:

## Sensor/Instrument Description:

- Net radiation sensor: REBS Q*4
- Method of calculating **Rn**: Averaged 15 second samples from single net radiometer.
- Soil heat flux sensor: REBS HFT 1
- Upper layer heat storage sensor: Four-probe thermocouples in parallel.
- Method of calculating **G(1)**: Averaged 15 second samples from three plates.
- Method of calculating **G(2)**: Averaged 15 second samples from three dT/dt measurements.
- Heat capacity equation: **C(s) = rho(s) (0.785 + 4.18 RWC)**

- Bowen ratio sensors: Dual **T - T(w)** fan-aspirated Ni-Fe resistance temperature detectors (used with mechanical exchanger).
- Lower arm height: 10 cm (measured above canopy)
- Lower-upper arm separation: 0.9 m
- Pressure parameter in specified psychrometric constant
- Temperature and vapor: 15 second sampling frequency
- Exchange frequency: 5 minutes
- Duty cycle for 30 minutes: 50% averaging period

For more information on the instrumentation used to collect these data, see Gay and Greenberg 1985.

**Collection Environment:**

Ground-based.

**Source/Platform:**

Ground.

**Source/Platform Mission Objectives:**

The principal reason to collect these data was to measure the fluxes of sensible and latent heat using the Bowen ratio-energy balance technique.

**Key Variables:**

Latent heat flux, net radiation, sensible heat flux, surface soil heat flux, incoming solar radiation, photosynthetically active radiation, Bowen ratio, wind speed, soil temperature, air temperature, and vapor pressure.

**Principles of Operation:**

The Bowen Ratio (BR) system used in this study employed dual psychrometer heads mounted on mechanical exchange systems to eliminate sensor biases (see Gay and Greenberg 1985, Fritschen and Simpson 1989).

Each BR system calculated Beta from mean values of the vertical gradients of temperature (**T**) and vapor pressure (**e**) over the 30 minute averaging period and with the known surface pressure (**P**) and psychrometeric constant (**gamma**):

**Beta = gamma (DELTA(T') / DELTA(e)) P / P(o)**

Where **P(o)** is the reference pressure used in gamma.

The BR system used in this study obtaining ground flux by using heat flux panels that were inserted below the surface (nominally 5 cm, to avoid radiative contamination) to obtain the soil

flux (**G1**). Above this critical level, soil temperature probes were inserted to enable the calculation of upper layer heat storage (**G2**), using a heat capacity (**Cs**) approach (see Kanemasu et al. 1992).

**Sensor/Instrument Measurement Geometry:**

Not available at this revision.

**Manufacturer of Sensor/Instrument:**

Sonic anemometers:

Campbell Scientific
P.O. Box 551
Logan UT 84321

and

Kaijo Denki Co., Ltd.
No. 19.1 - Chrome Kanda-Nishikicho
Chiyoda-Ku
Tokyo 101, Japan.

Fine-wire thermocouple:

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

Lyman-alpha Hygrometer:

Atmospheric Instrumentation Research, Inc.
1880 South Flatiron Court
Boulder, CO 80301.

Soil heat transducer:

Radiation & Energy Balance Systems, Inc. (REBS)
P.O. Box 15512
Seattle, WA 98115-0512.

Pyranometer:

Eppley Laboratories
Newport, RI.

Net radiometer:

Radiation & Energy Balance Systems, Inc. (REBS)
P.O. Box 15512
Seattle, WA 98115-0512.

Quantum sensor:

LI-COR, Inc.
4421 Superior Street
P.O. Box 4425
Lincoln, NE 68504.

Psychrometer:

EnviroMet Instrument Company
90 Calle Encanto
Tucson, AZ 85716.

Cup anemometer:

Cayuga Development
Ithaca, NY.

Data logging system:

IBM.

## Calibration:

A net radiometer calibration was accomplished using a transfer pyheliometer standard on loan from the Solar Energy Research Institute.

**Specifications:**

Not available at this revision.

**Tolerance:**

Not available at this revision.

**Frequency of Calibration:**

Several of the radiometers were calibrated by the shading technique and compared over the succeeding 24 hour period using data collected every 5 minutes. In 1989, a two day period was set aside for flux comparisons.

**Other Calibration Information:**

Soil heat flux plates were calibrated in several laboratories under different conditions.

- Sonic anemometer: supplied by the manufacturer.
- CO2 sensor: calibrated against known standard gases in the field.
- Lyman-alpha Hygrometer: calibrated in a chamber in which humidity could be controlled.
- Pyranometer: supplied by the manufacturer.
- Net radiometer: supplied by the manufacturer.
- Quantum sensor: supplied by the manufacturer.
- Soil heat transducer: supplied by the manufacturer.
- Psychrometer (RTDs): calibrated in a water bath.
- Cup anemometer: calibrated in a wind tunnel.

# 5. Data Acquisition Methods:

The data were acquired by a sensor system which is designed to retrieve all major components of the surface energy budget along with a large set of measured and derived parameters describing the dynamical, thermodynamical, hydrological, and radiative properties of the ground surface and atmosphere surface layer.

Sampling, recording, and near real-time processing of the data were done with a microcomputer.

# 6. Observations:

## Data Notes:

Not available.

## Field Notes:

Not available at this revision.

# 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 collected at the following locations within the FIFE study area. Stations that have the same GRID ID are located within 100 meters of each other. The stations whose GRID IDs end with ROV were equipped with a portable bowen ratio system which visited the location for only a few days. All other stations were equipped with stationary systems which spent many months at the location.

| GRID_ID | STN_ID | LATITUDE | LONGITUDE | NORTHING | EASTING | ELEV (ft.) |
|---|---|---|---|---|---|---|
| 1478-ROV | 79 | 39 06 15 | -96 26 56 | 4331216 | 720613 | 350 |
| 1816-BRK | 802 | 39 05 59 | -96 35 32 | 4330410 | 708225 | 345 |
| 1916-BRK | 902 | 39 05 55 | -96 35 30 | 4330282 | 708259 | 351 |
| 1916-ROV | 70 | 39 05 56 | -96 35 30 | 4330296 | 708263 | 340 |
| 1935-BRK | 812 | 39 05 49 | -96 32 58 | 4330195 | 711927 | 425 |
| 2132-BRK* | 6 | 39 05 36 | -96 33 23 | 4329774 | 711336 | 405 |
| 2133-BRK | 60 | 39 05 34 | -96 33 15 | 4329720 | 711521 | 405 |
| 2133-BRK | 806 | 39 05 34 | -96 33 12 | 4329726 | 711604 | 443 |
| 2330-BRK | 908 | 39 05 22 | -96 33 35 | 4329314 | 711066 | 424 |
| 2516-BRK | 14 | 39 05 12 | -96 35 38 | 4328956 | 708102 | 405 |
| 2655-ROV | 78 | 39 04 58 | -96 30 08 | 4328712 | 716057 | 365 |
| 2831-ROV | 71 | 39 04 55 | -96 33 32 | 4328497 | 711147 | 445 |
| 2915-BRK | 12 | 39 04 47 | -96 35 42 | 4328167 | 708028 | 415 |
| 3128-BRK | 808 | 39 04 32 | -96 33 52 | 4327780 | 710683 | 433 |
| 3129-BRK | 8 | 39 04 30 | -96 33 51 | 4327702 | 710711 | 430 |
| 3129-BRK | 912 | 39 04 33 | -96 33 47 | 4327822 | 710820 | 431 |
| 3479-ROV | 77 | 39 04 02 | -96 26 49 | 4327137 | 720894 | 420 |
| 3317-BRK | 910 | 39 04 22 | -96 35 24 | 4327395 | 708485 | 427 |
| 3317-BRK | 810 | 39 04 24 | -96 35 25 | 4327463 | 708463 | 420 |
| 3409-BRK | 814 | 39 04 18 | -96 36 32 | 4327244 | 706850 | 420 |
| 3414-BRK | 10 | 39 04 19 | -96 35 51 | 4327286 | 707854 | 410 |
| 4268-ROV | 76 | 39 03 15 | -96 28 27 | 4325623 | 718576 | 445 |
| 4439-ROV | 73 | 39 03 07 | -96 32 28 | 4325218 | 712794 | 445 |
| 4609-ROV | 74 | 39 03 02 | -96 36 41 | 4324895 | 706705 | 390 |
| 6912-ROV | 75 | 39 00 29 | -96 36 21 | 4320180 | 707308 | 385 |
| 6942-ROV | 72 | 39 00 23 | -96 32 04 | 4320158 | 713497 | 415 |

| GRID_ID | SLOPE | ASPECT (Deg.) |
|---|---|---|
| 1478-ROV | | |
| 1816-BRK | 2 | N |
| 1916-BRK | 2 | N |
| 1916-ROV | | |
| 1935-BRK | 20 | N |
| 2132-BRK | | |
| 2133-BRK | | |
| 2133-BRK | 14 | S |
| 2330-BRK | 5 | E |
| 2516-BRK | | |
| 2655-ROV | | |
| 2831-ROV | | |
| 2915-BRK | | |
| 3128-BRK | 5 | SE |
| 3129-BRK | | |
| 3129-BRK | 14 | E |
| 3479-ROV | | |
| 3317-BRK | 15 | W |
| 3317-BRK | 13 | W |

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3409-BRK     12        E
3414-BRK
4268-ROV
4439-ROV
4609-ROV
6912-ROV
6942-ROV
```

Note: Site 6 was instrumented only during IFC-1. The instrumentation at this location was moved to site 60 for IFC's 2-4.

**Spatial Coverage Map:**

Not available.

**Spatial Resolution:**

These are point data except that the Bowen ratio flux instruments effectively sample fluxes from an area about 100 meters upwind of the sensors.

**Projection:**

Not available.

**Grid Description:**

Not available.

## Temporal Characteristics:

**Temporal Coverage:**

Surface flux data in this data set were collected from May 29, 1987 through August 13, 1989. During this period there are three periods of extensive measurement; May 29 through August 13, 1987, April 27 through September 15, 1988, and July 22 through August 13, 1989. During this overall time period there are 298 days of data.

**Temporal Coverage Map:**

Not available.

**Temporal Resolution:**

The data values are 30 minute averages of the measured values; sampling was performed at 15 second intervals.

Measurements are daily from May 29 - September 22, 1987; October 2 - 19, 1987; April 27 - June 3, 1988; June 15 - August 8, 1988; August 27 - September 15, 1988; and July 22 - August 13, 1989. There are no measurements between these periods.

## Data Characteristics:

The SQL table definition for this data 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 here.

| **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<br>The net radiation, including both downward and upward energy. | [Watts] [meter^-2] |
| SENSIBLE_HEAT_FLUX<br>The sensible heat flux, the flux of the energy due to temperature differences. | [Watts] [meter^-2] |
| SOIL_HEAT_FLUX<br>The surface soil heat flux, the flux of energy into the soil. | [Watts] [meter^-2] |
| DIFFUSE_SOLAR_RADTN_DOWN<br>The downward (incoming) diffuse solar radiation. | [Watts] [meter^-2] |
| SOLAR_RADTN_DOWN<br>The downward (incoming) solar radiation. | [Watts] [meter^-2] |
| SOLAR_RADTN_UP<br>The upward (outgoing) solar radiation. | [Watts] [meter^-2] |
| PAR_DOWN<br>The downward (incoming) photo-synthetically active radiation (PAR). | [Watts] [meter^-2] |
| PAR_UP<br>The upward (outgoing) photo-synthetically active radiation (PAR). | [Watts] [meter^-2] |
| SOIL_TEMP_0_TO_25MM<br>The soil temperature recorded somewhere between 0 and 25 mm in depth. At Sitegrid 2133-BRK, this is an average from 0 to 75 mm. | [degrees Celsius] |
| SOIL_TEMP_25MM_TO_5CM<br>The soil temperature recorded somewhere between 25 mm and 5 cm in depth. At Sitegrid 2133-BRK, this is an average from 0 to 75 mm. | [degrees Celsius] |
| SOIL_TEMP_5_TO_10CM<br>The soil temperature recorded | [degrees |

somewhere between 5 and 10 cm in depth. Celsius]
At Sitegrid 2133-BRK, this is an average
from 0 to 75 mm. For 1988 data it is at 8 cm.

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SOIL_TEMP_10_TO_20CM
The soil temperature recorded [degrees
somewhere between 10 and 20 cm in depth. Celsius]
At Sitegrid 2133-BRK, this is at 11 cm.

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SOIL_TEMP_20_TO_50CM
The soil temperature recorded [degrees
somewhere between 20 and 50 cm in depth. Celsius]
Sitegrid 2133-BRK: 50 cm, 2516-BRK:
50 cm, 2915-BRK: 30 cm, 3129-BRK: 21 cm,
3414-BRK: 50 cm.

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RAINFALL
The amount of rainfall in this 30 minutes. [mm]

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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. [meters]
minutes [sec^-1]

---

WIND_DIR
The average wind direction in this [degrees
30 minutes. from North]

---

AIR_TEMP_HIGH
The air temperature at the higher [degrees
level. This is the higher of the movable Celsius]
sensor arms.

---

DELTA_TEMP
The difference in air temperature between [degrees
the higher and lower level (AIR_TEMP_HIGH Celsius]
- AIR_TEMP_LOW).

---

VAPOR_PRESS_HIGH
The vapor pressure at the higher level. [kiloPascals]
This is the higher of the movable sensor
arms.

---

DELTA_VAPOR_PRESS

```
The difference in the vapor pressure                          [kiloPascals]
between the higher and lower level
(VAPOR_PRESS_HIGH - VAPOR_PRESS_LOW).
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```
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).
```

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```
LAST_REVISION_DATE
in the format (DD-MMM-YY).
```

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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 fields in the surface flux record but only those fields that are described here (i.e., reported by G. Asrar and E. Kanemasu) contain data.

| SITEGRID_ID | STATION_ID | OBS_DATE | OBS_TIME | LATENT_HEAT_FLUX |
|---|---|---|---|---|
| 1816-BRK | 802 | 28-MAY-88 | 1215 | -99 |
| 1816-BRK | 802 | 28-MAY-88 | 1245 | -102 |
| 1816-BRK | 802 | 28-MAY-88 | 1315 | -144 |
| 1816-BRK | 802 | 28-MAY-88 | 1345 | -178 |

| NET_RADTN | SENSIBLE_HEAT_FLUX | SOIL_HEAT_FLUX | DIFFUSE_SOLAR_RADTN_DOWN |
|---|---|---|---|
| 29 | 50 | 20 | 53 |
| 100 | -12 | 14 | 79 |

206 -70 7 118
264 -89 3 130

| SOLAR_RADTN_DOWN | SOLAR_RADTN_UP | SOLAR_RADTN_NET | SOLAR_RADTN_DOWN_SDEV |
|---|---|---|---|
| 111 | 43 | | |
| 206 | 74 | | |
| 347 | 108 | | |
| 422 | 122 | | |

| SOLAR_RADTN_UP_SDEV | PAR_DOWN | PAR_UP | SURF_ALBEDO |
|---|---|---|---|
| 234.62 | 16.08 | | |
| 437.61 | 31.64 | | |
| 735.12 | 51.35 | | |
| 907.22 | 60.69 | | |

| 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 |
|---|---|---|
| 18.82 | | |
| 18.66 | | |
| 18.46 | | |
| 18.27 | | |

| SOIL_TEMP_10_TO_20CM | SOIL_TEMP_20_TO_50CM | RAINFALL | BOWEN_RATIO |
|---|---|---|---|
| 0 | -.503 | | |
| 0 | .119 | | |
| 0 | .484 | | |
| 0 | .501 | | |

| WIND_SPEED | WIND_DIR | WIND_SPEED_MIN | WIND_SPEED_MAX | WIND_SPEED_SDEV |
|---|---|---|---|---|
| 4.3 | 169 | | | |
| 4.8 | 170 | | | |
| 4.9 | 177 | | | |
| 4.6 | 180 | | | |

| 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 |
|---|---|---|---|
| 18.5 | | | |
| 20 | | | |
| 21.6 | | | |
| 22.2 | | | |

| AIR_TEMP_OTHER | AIR_TEMP_MEAN | AIR_TEMP_MEAN_SDEV | AIR_TEMP_OTHER_SDEV |
|---|---|---|---|

| DELTA_TEMP | WET_BULB_TEMP_LOW | WET_BULB_TEMP_HIGH | VAPOR_PRESS_LOW |
|---|---|---|---|

```
----------   -----------------   ------------------   ---------------
.14
-.05
-.27
-.36
VAPOR_PRESS_HIGH   VAPOR_PRESS_MEAN   VAPOR_PRESS_SDEV   REL_HUMID_LOW
----------------   ----------------   ----------------   -------------
1.21
1.26
1.32
1.38
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
------------------
01-NOV-89
01-NOV-89
01-NOV-89
01-NOV-89
```

# 8. Data Organization:

## Data Granularity:

These are point data except that the Bowen ratio flux instruments effectively sample fluxes from an area about 100 meters upwind of the sensors. Surface flux data in this data set were collected from May 29, 1987 through August 13, 1989.

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:

Not available at this revision.

### Derivation Techniques and Algorithms:

Not provided by Principal Investigator.

## Data Processing Sequence:

### Processing Steps:

Not available at this revision.

### Processing Changes:

Not available at this revision.

## Calculations:

### Special Corrections/Adjustments:

Not available at this revision.

### Calculated Variables:

Not available at this revision.

### Graphs and Plots:

None.

# 10. Errors:

### Sources of Error:

Not available at this revision.

### Quality Assessment:

It was recognized early in the study that standardizations 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 as 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:

Not available at this revision.

**Additional Quality Assessments:**

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

FIS staff applied a general 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. Inconsistencies and problems found in the QA check are described is 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:

Wind Speed values greater than 500 m/s, were reported on July 1, 1988 and July 2, 1988, at station 814 (3409-BRK).

Air temperatures measured by the upper arm of the Bowen ratio instrument are greater than 200 deg C, on July 4, 1988 at station 810 (3317-BRK), and greater than 100 deg C, on August 9, 1988 and August 10, 1988, at station 812 (1935-BRK).

Different missing values are used within each column. They may be positive or negative 9.9, 9.99, 99.99, 999.99, 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:

Note that sitegrid location 2132 (old station 6) was only used during IFC-1 (May-June, 1987). This was a slope site with serious difficulties, and most observations, including the Bowen ratio instruments, were moved between IFC-1 and IFC-2 to a level site on top of the ridge. This level top location is sitegrid 2133 (old station 60). Therefore, one should not attempt to construct a single continuous sequence of surface flux data from these data.

(Note that FIFE Information System staff attempted, to the best of their ability, to maintain the distinction between sites 6 and 60. This was not always easy to apply in the field, and many investigators referred to this general location as "site 6" throughout 1987 and to some extent 1989. Some data may have been submitted with the wrong site identifier by an investigator and slipped into the final data set collection. Be cautious in using data from these sites, and evaluate the accompanying documentation carefully.)

### Any Other Relevant Information about the Study:

Not available at this revision.

## 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:

The Bowen Ratio Surface Flux Observations (KSU) data are available on FIFE CD-ROM Volume 1. The CD-ROM filename is as follows:

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

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 .BRK for this data set.

# 17. References:

## Satellite/Instrument/Data Processing Documentation.

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Tanner, C.B. 1960. Energy balance approach to evapotranspiration from crops. Soil Sci. Soc. Amer. Proc. 24:1-9.

Verma, S.B. 1990. Micrometeorological methods for measuring surface fluxes of mass and energy. Remote Sensing Reviews. 5:99-115.

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:

BPI Byte per inch BREB Bowen Ratio Energy Balance CCT Computer Compatible Tape DAAC Distributive Active Archive Center EOSDIS Earth Observation System Data and Information System FIS FIFE Information System HFT Heat Flux Thermometer IFOV Instantaneous Field of View LAI Leaf area index Mbps Megabyte per second ORNL Oak Ridge National Laboratory PAMS Portable Automatic Mesonet REBS Radiation and Energy Balance Systems 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 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.

## Document Review Date:

October 14, 1996.

## Document ID:

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## Document Curator:

DAAC Staff

## Document URL:

http://daac.ornl.gov