Bowen Ratio Surface Flux: GSFC (FIFE)

Summary:

The Bowen Ratio Surface Flux Observations (GSFC) Data Set contains data collected using the Bowen Ratio Techniques. The major data collection effort was conducted in 1987 when 16 stationary sites were equipped with Bowen ratio equipment by different groups. Surface flux measurements were made at selected sites within the FIFE area. All measurements are from a single upland site that was grazed. This station measured the fluxes of net radiation, sensible heat, and latent heat and several micrometeorological parameters.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

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

Data Set Introduction:

The Bowen Ratio Surface Flux Observations (GSFC) Data Set contains data collected using the Bowen Ratio Techniques. The data set includes fluxes of net radiation, sensible heat, and latent heat and several micrometeorological parameters.

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, heat storage, soil moisture, soil temperature, rainfall, Bowen ratio, wind speed, wind direction, air temperature, and 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 by different groups. The data described here were collected using the Bowen Ratio techniques. Measurements were made daily during the 4 IFC's in 1987, spanning from late May to Mid-October. All measurements are from a single upland site that was grazed. This station measured the fluxes of net radiation, sensible heat, and latent heat and several micrometeorological parameters.

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 (KSU).
- 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. William Kustas
Agricultural Research Service

Title of Investigation:

Surface flux measurements by Bowen Ratio technique during FIFE.

Contact Information:

Contact 1:
Dr. William Kustas
USDA/ARS-ASRI
Beltsville, MD
Tel.: (301) 504-8498
Email: bkustas@hydrolab.arsusda.gov

Contact 2:
Richard T. Field
University of Delaware
Newark, DE
Tel.: (302) 831-2695
Email: rtfield@earthview.cms.udel.edu

Requested Form of Acknowledgment.

The Bowen Ratio Surface Flux Observations (GSFC) were collected under the direction of Dr. W. Kustas from U.S. Department of Agriculture. The contribution of these data is particularly 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 for 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 at the soil surface. **G(5)** is the soil heat flux observed at 5 cm depth, **S(2.5)** is the change in heat storage in the top 0 to 5 cm layer of the soil, **C** is soil heat capacity in the 0-5 cm depth layer and **del T(t)** is the change in 2.5 cm depth soil temperature during the 30 minute averaging period.

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

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

G = G(5) + del S(2.5) (4).

del S(2.5) = C del T(t) (5).

4. Equipment:

Sensor/Instrument Description:

The Bowen ratio system consists of two sensor arms, each 1.5 meters long, which suspend the temperature sensor and air intake for the humidity sensor over the canopy. The lower arm is 1.0 m above the vegetation canopy (1.10 m above the ground.) The upper arm is 2.25 m above the ground; thus temperature (**T**) and dew point (**Td**) gradients are defined over a height difference of 1.15 m. The temperature sensors are unshielded 1-mil copper-constant dual-bridge thermocouples. The dew point sensor is a General Eastern cooled mirror LED assembly which is fed air drawn from the upper and lower arm alternately on a three minute schedule through separate mixing chambers regulated for 6 minute time constants. The air flow rate into the mixing chambers is nominally set at 400 m^2/min. This system is described by Smith et al. 1992(a) and Tanner et al. 1987. Dew point is converted to vapor pressure (**e**) for subsequent computation.

The ground flux was obtained from three soil heat flux disks that were inserted below the surface (nominally 5 cm depth) to avoid radiative contamination) to obtain the soil flux (**G1**). Above this level, three soil temperature probes were inserted at 2.5 cm to enable the calculation of upper

layer heat storage (**G2**), using a heat capacity (**Cs**) approach (see Kanemasu et al. 1992). The soil heat flow disks were separately recorded. The three soil temperature thermocouples were read in parallel.

Soil wetness was observed with a gypsum block. The output soil moisture potential is in pressure (-bars).

The suite of instruments used and sampling features are listed below:

- Net Radiation Sensor: REBS Q*4
- Method of calculating Rn: Averaged 1 minute samples from a single net radiometer.
- Soil heat flux sensor REBS HFT 1.
- Upper layer heat storage sensor: Two-probe thermocouples in parallel.
- Method of calculating G1: Average of three plates, each of which is 30 minute average of 1 second samples.
- Method of calculating delta T(t): Difference between consecutive 30 minute averages, each of which is obtained from 1 second samples. dT/dt measurements.
- Heat capacity equation: **C(s) = rho(s) (0.785 + 4.18 RWC)**
- Bowen Ratio Sensor: CSI BR system with dual bridge 25 um
- TCs and dew point hygrometer: (TCs are unaspirated and unshielded; hygrometer is a single cooled mirror instrument fed by regulated pumps through mixing chambers alternately sampling the air from the upper arm and the lower arm).
- Lower arm height: 1.0 m, measured above canopy (1.15 m above ground).
- Lower-upper arm separation: 1.10 m
- Pressure parameter is calculated from site elevation.
- psychrometric constant
- Temperature and vapor sampling: 1 second frequency
- Exchange frequency: 2.5 min
- Duty cycle for 30 minute averaging: 60% period

Collection Environment:

Ground-based.

Source/Platform:

Ground.

Source/Platform Mission Objectives:

Observe components of the surface energy budget.

Key Variables:

Latent heat flux, net radiation, soil heat flux, sensible heat flux, heat storage, soil moisture, soil temperature, rainfall, Bowen ratio, air temperature, vapor pressure.

Principles of Operation:

Not available at this revision.

Sensor/Instrument Measurement Geometry:

Sensor heights on Bowen ratio apparatus:

Lower air temperature and air sample intake - 1.10 m above ground, nominally 1.0 m above canopy.

Upper air temperature and air sample intake - 2.25 m above ground, nominally 2.15 m above canopy.

Net Radiometer located 0.90 m above ground, nominally 0.8 m above canopy.

Wind Speed and Direction sensors located 3.2 m above ground.

Soil Moisture sensor located 0-5 cm depth below the soil surface.

Soil heat flux plates were located at a nominal 5.0 cm depth.

Soil temperature at nominal 2.5 cm depth.

Manufacturer of Sensor/Instrument:

Dewpoint hygrometer Bowen ratio apparatus (including air temperature thermocouples, air sampling apparatus and data logger):

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

Net Radiometer: Model Q*4:

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

Soil Heat Flux Transducers:

Radiation Energy Budget Systems
P.O. Box 15512
Seattle, WA 98115-0512

Rain Gage: Texas Electronics tipping bucket raingauge:

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

Wind Speed and Direction: R. M. Young Wind Sentry Wind Set

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

Soil Moisture:

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

Calibration:

Net Radiometer calibrated by manufacturer of net radiation. Adjustments to REBS Q*4 radiometer observations of net radiation are as discussed in Field et al. (1992).

Bowen ratio apparatus calibrated by manufacturer. Chilled mirror calibrated prior to 1987 field campaign using procedures recommended by General Eastern. Adjusted optical bias of mirror every few days during observations following manufacturers recommendations.

Soil Heat Flow disk calibrations as reported by manufacturer.

Soil Moisture gypsum blocks used manufacturer's calibration to convert voltages to bars.

Specifications:

Not available at this revision.

Tolerance:

Not available at this revision.

Frequency of Calibration:

Chilled mirror bias was adjusted approximately every three days while data were being collected.

Other Calibration Information:

Net radiometer compared to mobile Thornthwaite Miniature Net Radiometer during IFC 2, 3 and 4. Indicated stable comparison.

5. Data Acquisition Methods:

The data were acquired by the sensors and recorded on a Campbell Scientific CR 21X data logger recording 30 minute averages. The system is designed to retrieve all major components of the surface energy budget.

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:

This Surface Flux data was collected at the following location:

SITEGRID_ID	STN_ID	LATITUDE	LONGITUDE	NORTHING	EASTING	ELEVATION
4268-BRG	32	39 03 15	-96 28 27	4325626	718579	445

Spatial Coverage Map:

Not available.

Spatial Resolution:

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

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

These data were collected on 58 days from May 26, 1987 to October 16, 1987.

Temporal Coverage Map:

Not available.

Temporal Resolution:

The data values represent 30-minute mean values. Sampling is performed at 1 second intervals for the Bowen ratio, 1 minute intervals for the net radiation, and 1 second intervals for soil heat flux.

Measurements are daily during the 4 IFC's in 1987; May 26 - June 5, June 25 - July 12, August 5 - August 21, and October 5 - October 16.

Data Characteristics:

The SQL definition for this data table is found in the SF_30MIN.TDF file located on the FIFE CD-ROM Volume 1. The following chart lists only those variables that are contained in the data set described in this document. (i.e., those measured at sitegrid 4268-BRK).

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 200m 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 [GMT]
taken, in GMT. The format is HHMM.

LATENT_HEAT_FLUX
The latent heat flux, the flux of [Watts]
the energy due to the evaporation [meter^-2]
of water.

NET_RADTN
The net radiation, including both [Watts]
downward and upward energy. [meter^-2]

SENSIBLE_HEAT_FLUX
The sensible heat flux, the flux [Watts]
of the energy due to temperature [meter^-2]
differences.

SOIL_HEAT_FLUX
The surface soil heat flux, the [Watts]
flux of energy into the soil. [meter^-2]

SOIL_HEAT_FLUX_0_TO_5CM
The soil heat flux recorded [Watts]
somewhere between 0 and 5 cm in [meter^-2]
depth.

SOIL_HEAT_FLUX_5_TO_10CM
The soil heat flux recorded [Watts]
somewhere between 5 and 10 cm in [meter^-2]
depth.

SOIL_HEAT_FLUX_10_TO_20CM
The soil heat flux recorded [Watts]
somewhere between 10 and 20 cm in [meter^-2]
depth.

HEAT_STORAGE
The heat storage in the top soil [Watts]

layer.	[meter^-2]
SOIL_WATER_POTNTL_0_TO_5CM The soil water potential recorded somewhere between 0 and 5 cm in depth [bars]. This is the pressure required to extract water from the soil. At 15 bars, plants cannot extract any more water.	[bars]
SOIL_TEMP_0_TO_25MM The soil temperature recorded somewhere between 0 and 25 mm in depth. Recorded at 25 mm.	[degrees Celsius]
RAINFALL The amount of rainfall in this 30 minutes.	[mm]
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]
AIR_TEMP_LOW The air temperature at the lower level. This is the lower of the movable sensor arms.	[degrees Celsius]
AIR_TEMP_HIGH The air temperature at the higher level. This is the higher of the movable sensor arms.	[degrees Celsius]
DELTA_TEMP The difference in air temperature between the higher and lower level (AIR_TEMP_HIGH - AIR_TEMP_LOW).	[degrees Celsius]

```
VAPOR_PRESS_LOW
The vapor pressure at the lower                          [kiloPascals]
level. This is the lower of the
movable sensor arms.
```

```
VAPOR_PRESS_HIGH
The vapor pressure at the higher                         [kiloPascals]
level. 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).
```

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

Footnotes:

* Valid levels

The primary certification codes are:

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

The certification code modifiers are:

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

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

Sample Data Record:

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

SITEGRID_ID	STATION_ID	OBS_DATE	OBS_TIME	LATENT_HEAT_FLUX
4268-BRG	32	14-AUG-87	2115	-397.268
4268-BRG	32	14-AUG-87	2145	-248.352
4268-BRG	32	14-AUG-87	2215	-241.901
4268-BRG	32	14-AUG-87	2245	-225.037

NET_RADTN	SENSIBLE_HEAT_FLUX	SOIL_HEAT_FLUX	DIFFUSE_SOLAR_RADTN_DOWN
501.532	-74.264	-30	
347.231	-55.879	-43	
302.376	-60.475	0	
259.315	-46.278	12	

SOLAR_RADTN_DOWN	SOLAR_RADTN_UP	SOLAR_RADTN_NET	SOLAR_RADTN_DOWN_SDEV

SOLAR_RADTN_UP_SDEV	PAR_DOWN	PAR_UP	SURF_ALBEDO

LONGWAVE_RADTN_DOWN	LONGWAVE_RADTN_UP	LONGWAVE_RADTN_NET

BB_TEMP_LONGWAVE_DOWN	BB_TEMP_LONGWAVE_UP	TOTAL_RADTN_DOWN

TOTAL_RADTN_UP	SOIL_HEAT_FLUX_0_TO_5CM	SOIL_HEAT_FLUX_5_TO_10CM
54	-64	
48	-59	
32	-41	
21	-27	

SOIL_HEAT_FLUX_10_TO_20CM	HEAT_STORAGE	SOIL_WATER_POTNTL_0_TO_5CM
-59	29	.26
-59	12	.27
-44	39	.27
-34	39	.27

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
32.01		
31.87		
31.37		
30.87		

SOIL_TEMP_10_TO_20CM	SOIL_TEMP_20_TO_50CM	RAINFALL	BOWEN_RATIO
0	.19		
0	.22		
0	.25		
0	.21		

WIND_SPEED	WIND_DIR	WIND_SPEED_MIN	WIND_SPEED_MAX	WIND_SPEED_SDEV
7.44	151			
7.92	147			
7.56	160			
7.41	157			

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_HIGH   AIR_TEMP_LOW
-------------------   --------------------   -------------   ------------
31.99           31.69
31.58           31.38
31.47           31.33
31.75           31.64
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
----------   -----------------   -------------------   ---------------
-.297                                                   3.29
-.203                                                   3.32
-.144                                                   3.35
-.112                                                   3.33
VAPOR_PRESS_HIGH    VAPOR_PRESS_MEAN   VAPOR_PRESS_SDEV   REL_HUMID_LOW
-----------------   ----------------   -----------------   -------------
3.19
3.26
3.32
3.29
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
------------------   ----------   ----------   ---------------------
CGR-PJS
CGR-PJS
CGR-PJS
CGR-PJS
LAST_REVISION_DATE
------------------
21-SEP-93
21-SEP-93
21-SEP-93
21-SEP-93
```

8. Data Organization:

Data Granularity:

These are point data except that the Bowen ratio flux instruments effectively sample fluxes from an area of about 100 meters upwind of the sensors. These data were collected on 58 days from May 26, 1987 to October 16, 1987. The data values represent 30 minute mean values.

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:

Bowen ratio (**Beta**) was calculated from the mean values of the vertical gradients of temperature (**T**) and vapor pressure (**e**) over the 30 minute averaging period using the surface pressure (**P**) and psychrometric constant (**gamma**):

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

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

Ground heat flux:

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

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

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

where:

G(t) is the ground heat flux at the soil surface at time **t** integrated over ½

hour time interval **delt G1(t)** is the soil heat flux at 5.0 cm depth averaged between three soil heat flux plates over **delt**;

S(t) is the change in heat stored in the soil between the surface and 5 cm depth during the time interval **delt.**

C is the volumetric heat capacity of the soil [J][m^-3][K^-1] according to de Vries (1975)

del T(t) is the change in soil temperature over time **delt**, measured from three parallel thermocouples.

rhob is the bulk density of the soil (1036 [kg][m^-3])

rhom is the density of the soil mineral constituents (2.65 [g][cm^-3]

rhoo is the density of the soil organic constituent (1.3 [g][cm^-3])

qm is the weight fraction of mineral matter in the soil (0.95)

qo is the weight fraction of organic matter in the soil (0.05)

qw is the weight fraction of water in the soil (variable)

The weight fraction of water, **qw**, was obtained from 5 bulk soil samples obtained by FIFE staff once per day at the site described here (sitegrid id = 4268) generally between the hours of 1000 and 1300 during the IFC. All 5 samples were used.

Derivation Techniques and Algorithms:

Not available at this revision.

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:

Not available at this revision.

10. Errors:

Sources of Error:

Not available at this revision.

Quality Assessment:

Comparison of fluxes reported here with the roving fluxes from the energy balance system showed differences in **E** of around 5%. See Nie et al. (1992) for details.

Data Validation by Source:

Not available at this revision.

Confidence Level/Accuracy Judgment:

Not available at this revision.

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. The data have also been checked for energy imbalances. 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 fields. 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:

Due to recalculated values of net radiation performed by the FIFE Surface Flux Group in 1991, the estimated fluxes of H & E reported here will be slightly different. For closure of the surface energy balance (see Equation 2 in the *Theory of Measurements Section*), it is suggested that users of the data described here recalculate H and E with the Q-values given in this data set (these are recalculated values), using the Bowen ratio and G-values given here (see Equation 3 the *Theory of Measurements Section*).

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

Not available at this revision.

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:

Bowen Ratio Surface Flux Observations (GSFC) data are available on FIFE CD-ROM Volume 1. The CD-ROM filename is as follows:
\DATA\SUR_FLUX\30_MIN\GRIDxxxx\YyyMmm\ydddgrid.BRG or
\DATA\SUR_FLUX\30_MIN\GRIDxxxx\Yyyyy\ydddgrid.BRG

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 .BRG for this data set.

17. References:

Satellite/Instrument/Data Processing Documentation.

Tanner, B.D., J.P. Greene, and G.E. Bingham. 1987. A Bowen ratio design for long-term measurements. Am. Soc. of Agric. Eng., St Joseph Mich, ASAE Tech. Pap. 87-2503.

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Smith, E.A., W.L. Crosson, and B.D. Tanner. 1992(a). Estimation of surface heat and moisture fluxes over a prairie grassland, 1, In situ energy budget measurements incorporating a cooled mirror dew point hygrometer. J. Geophys. Res. 97(D17):18,557-18582.

Smith, E.A., A.Y. Hsu, W.L. Crosson, R.T. Field, L.J. Fritschen, R.J. Gurney, E.T. Kanemasu, W.P. Kustas, D. Nie, W.J. Shuttleworth, J.B. Stewart, S.B. Verma, H.L. Weaver and M.L. Wesley 1992(b). Area-average surface flux and their time-space variability over the FIFE experimental domain. J. Geophys. Res. 97(D17):18,599-18,622.

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 BR Bowen Ratio CCT Computer Compatible Tape CSI Campbell Scientific Instruments DAAC Distributive Active Archives Center EOSDIS Earth Observation System Data and Information System FIS FIFE Information System GSFC Goddard Space Flight Center 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 RWC Gravimetrically Obtained "Fraction Soil Moisture by Mass" TC Thermocouple URL Uniform Resource Locator

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

20. Document Information:

April 28, 1994 (citation revised on October 15, 2002).

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

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