Bowen Ratio Surf. Flux: Fritschen (FIFE)

Summary:

Surface flux measurements were made at selected sites within the FIFE area. Each surface flux station was capable of measuring the fluxes of net radiation, sensible heat, and latent heat. The Bowen ratio stations measured the soil heat flux as well. The surface flux and micrometeorological measurements available in this data set were collected from 15 locations within the FIFE study area between 1987 and 1989.

Six automatic surface energy and radiation balance systems were operated continuously for 144 days from May 16 to October 16, 1987. Variables including net radiation, air temperature, vapor pressure and wind speed, were quite similar for the sites even though the sites were as much as 10 km apart and represented the four cardinal slopes and a top.

The Bowen ratio was low during most of the season, increasing sharply toward the end of the season after a long dry spell. The average Bowen ratio was 0.35. About 72% of the available energy was converted into latent heat flux density. Since the data systems and instrumentation used were of similar design, the variability in results can be ascribed to treatment and locations. These results can be used to estimate the number of stations needed to represent a rolling prairie topography.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Bowen Ratio Surf. Flux: Fritschen (FIFE).
(Bowen Ratio Surface Flux Observations (Fritschen)).

Data Set Introduction:

The Bowen Ratio Surface Flux Observations (Fritschen) Data Set contains fluxes of net radiation, sensible heat, and latent heat collected from 15 locations within the FIFE study area between 1987 and 1989.

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. The data in this data set was collected to evaluate the variation in data from the stations which were of similar design and operation, located on slopes with different aspects.

Summary of Parameters:

Latent heat flux, net radiation, sensible heat flux, soil heat flux, incoming diffuse solar radiation, incoming solar radiation, outgoing solar radiation, heat storage, soil temperature, Bowen ratio, wind speed, wind direction, air temperature, delta temperature, wet bulb temperature, vapor pressure, delta vapor pressure, relative humidity.

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 operated by several different groups. In 1988 and 1989, Bowen ratio surface flux stations were installed at 12 and 19 sites, respectively. Each surface flux station was capable of measuring the fluxes of net radiation, sensible heat, and latent 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 15 locations within the FIFE study area during each of 3 years, 1987, 1988, and 1989. During these years measurements were made at many of the same locations from one year to the next. There are about 213 days of data in this data set. About half of these are in the Spring, Summer, and Fall of 1987. In 1989 data are only available for late July and early August.

Six automatic surface energy and radiation balance systems were operated continuously for 144 days from May 16 to October 16, 1987. Variables including net radiation, air temperature, vapor pressure and wind speed, were quite similar for the sites even though the sites were as much as

10 km apart and represented the four cardinal slopes and a top. Daily average net radiation was 13.7 +/- 0.15 MJ [m^2 day]^-1. The largest percentage differences between sites occurred in soil heat flux density, 1.40 +/- 0.37 MJ [m^2 day]^-1. The latent heat flux density averaged 9.1 +/- 0.54 [m^2 day]^-1 or -3.7 +/- 0.22 mm [m^2 day]^-1. The accumulated amount was -536 +32 mm [m^2]^-1.

The Bowen ratio was low during most of the season, increasing sharply toward the end of the season after a long dry spell. The average Bowen ratio was 0.35. About 72% of the available energy was converted into latent heat flux density. Since the data systems and instrumentation used were of similar design, the variability in results can be ascribed to treatment and locations. These results can be used to estimate the number of stations needed to represent a rolling prairie topography.

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 (KSU).
- 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. Leo J. Fritschen
College of Forest Resources

Title of Investigation:

Evaluation of surface radiation and energy budget stations for FIFE.

Contact Information:

Contact 1:
Dr. Leo J. Fritschen

University of Washington
Seattle, WA
Telephone: (206) 543-1584

Email: leojf@max.u.washington.edu

Requested Form of Acknowledgment.

The Bowen Ratio Surface Flux Observations (Fritschen) were collected by Dr. Leo J. Fritschen of the University of Washington. 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 system 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 from 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 30 second samples from single net radiometer.
- Soil heat flux sensor: REBS HFT 1
- Upper layer heat storage sensor: Three-probe PRTs in parallel.
- Method of calculating G(1): Average 30 second samples from three plates.
- Method of calculating G(2): Average 30 second samples from three dT/dt measurements.
- Heat capacity equation: **C(s) = 10^6 (0.804 + 4.23 RWC)**
- Bowen radio sensors: Dual T - T(w) fan-aspirated PRT psychrometers (used with mechanical exchanger).
- Lower arm height: 10 cm (measured above canopy).
- Lower-upper arm separation: 1.0 m
- Pressure parameter in specified psychrometric constant
- Temperature and vapor: 30 second sampling frequency
- Exchange frequency: 6 minutes
- Duty cycle for 30 minute: 50% averaging period

For more detail on the instrumentation used to collect these data see Fritschen and Simpson 1989.

Collection Environment:

Ground-based.

Source/Platform:

Ground.

Source/Platform Mission Objectives:

The principal objective for collecting 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, soil heat flux, incoming solar radiation, heat storage, mean soil temperature, Bowen ratio, wind speed and direction, air temperature, vapor pressure, relative humidity.

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 using the known 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.

The BR system used in this study measured soil flux by using heat flux panels that were inserted below the surface of the earth (nominally 5 cm, to avoid radiative contamination). 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, Inc.
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.
- 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:

Data from the six sites were obtained using the Surface Energy and Radiation Balance System (SERBS), which is an automatic system for processing of surface energy and radiation balance data. The SERBS used in this study were improved versions of those used in the ASCOT84 experiment. A detailed description of the SERBS, its data acquisition system, sensors and automatic exchange mechanism was given by Fritschen and Simpson 1989, and is not duplicated here.

Ceramic wick psychrometers were used to measure air and wet bulb temperatures. Ceramic wicks were used because they are aerodynamically uniform and have consistent porosities. One-bar low flow wicks which were supplied with water from a constant head reservoir of 2 cm was used. Very consistent wet bulb temperatures were obtained using these wicks.

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

6. Observations:

Data Notes:

Not available.

Field Notes:

During the 1987 experiment, a 200 Kbyte 3.5 inch floppy drive was used for field data storage. The floppy held eight days of data (17 channels plus 2 date-time groups) stored as 6 minute averages. Out of 864 station days of data collected in 1987, about 1% of the data were lost due to failure of either the floppy disk or the drives. This loss of data was eliminated in 1988 by using a laptop computer containing a 720 kbyte floppy drive.

INFORMATION FOR GOLDEN DAYS* FOR SITES 20, 34, 36, 40, 42 AND 44

Sitegrid deg	Stn_ID deg	Aspect System Used	Slope	Bowen Ratio
6340-BRL	20	242	7	8
3479-BRL	34	123	10	2
2655-BRL	36	122	3	7
1246-BRL	40	180	7	9
1445-BRL	42	35	5	3
2043-BRL	44	RIDGE	TOP	1

* = (June 6, 1987, July 14, 1987, August 15, 1987, October 11, 1987)

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 SITEGRID_ID are located within 100 meters of each other.

SITEGRID	STN_ID	LATITUDE	LONGITUDE	EASTING	NORTHING	ELEV (FT)
1246-BRL	40	39 06 35	-96 31 21	714212	4331666	365
1246-BRL	840	39 06 34	-96 31 22	714200	4331625	410
1445-BRL	42	39 06 19	-96 31 27	714090	4331160	400
1942-BRL	944	39 05 46	-96 31 56	713414	4330133	422
2043-BRL	44	39 05 42	-96 31 51	713536	4330003	415
2133-BRL	904	39 05 34	-96 33 13	711576	4329704	443
2655-BRL	36,836,936	39 05 00	-96 30 07	716070	4328787	367
3479-BRL	34	39 04 02	-96 26 49	720890	4327134	420
4268-BRL	932	39 03 16	-96 28 26	718582	4325633	420
4268-BRL	834	39 03 16	-96 28 30	718500	4325630	420
4439-BRL	844	39 03 08	-96 32 30	712730	4325230	445
6340-BRL	20	39 01 06	-96 32 23	713000	4321484	410

6340-BRL	820	39 01 07	-96 32 23	713000	4321500	410
6735-BRL	842,913	39 00 40	-96 33 03	712073	4320652	385
6912-BRL	924	39 00 26	-96 36 20	707336	4320111	397

SLOPE	ASPECT (DEG)
12	S
1	TOP
1	TOP
4	E
1	TOP
1	TOP
2	N
4	SW
1	BOTTOM
2	N

Spatial Coverage Map:

Not available.

Spatial Resolution:

These are the 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 for the FIFE project were collected from May 26, 1987 through October 17, 1987, and July 18, 1989 through August 12, 1989.

Temporal Coverage Map:

Not available.

Temporal Resolution:

The data values are 30 minute averages of the measured values.

Sampling was performed at 30 second intervals.

Measurements are daily from May 26 - October 17, 1987, and July 22 - August 13, 1989. In 1988 measurements were concentrated in June, July, August and September.

Data Characteristics:

The SQL table definition for this data table is found in the SF_30MIN.TDF site located on FIFE CD-ROM Volume 1.

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]
DIFFUSE_SOLAR_RADTN_DOWN The downward (incoming) diffuse solar radiation.	[Watts] [meter^-2]
SOLAR_RADTN_DOWN The downward (incoming) solar radiation.	[Watts] [meter^-2]
SOLAR_RADTN_UP The upward (outgoing) solar radiation.	[Watts] [meter^-2]
SOIL_HEAT_FLUX_0_TO_5CM The soil heat flux recorded somewhere between 0 and 5 cm in depth.	[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. Average from 0 to 5 cm, same as in SOIL_TEMP_25MM_TO_5CM.	[degrees Celsius]
SOIL_TEMP_25MM_TO_5CM The soil temperature recorded somewhere between 25 mm and 5 cm in depth. Average from 0 to 5 cm, same as in SOIL_TEMP_0_TO_25MM.	[degrees Celsius]
BOWEN_RATIO The Bowen Ratio, the ratio of the SENSIBLE_HEAT_FLUX to the LATENT_HEAT_FLUX.	

WIND_SPEED The average wind speed in this 30 minutes.	[meters] [sec^-1]
WIND_DIR The average wind direction in this 30 minutes.	[degrees from North]
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]
WET_BULB_TEMP_HIGH The wet bulb temperature at the higher level. This is the higher of the movable sensor arms.	[degrees Celsius]
VAPOR_PRESS_HIGH The vapor pressure at the higher level. This is the higher of the movable sensor arms.	[kiloPascals]
DELTA_VAPOR_PRESS The difference in the vapor pressure between the higher and lower level (VAPOR_PRESS_HIGH - VAPOR_PRESS_LOW).	[kiloPascals]
REL_HUMID_LOW The relative humidity at the lower level. This is the lower of the movable sensor arms.	[percent]
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 may be positive or negative 9.9, 9.99, 99.99, 999, 999.99, 9999, or 99999.99.

Sample Data Record:

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

```
SITEGRID_ID  STATION_ID   OBS_DATE    OBS_TIME   LATENT_HEAT_FLUX
-----------  ----------  ---------   ----------  ----------------
6735-BRL        913      28-JUL-89      1215          -5
6735-BRL        913      28-JUL-89      1245         -48
6735-BRL        913      28-JUL-89      1315         -82
6735-BRL        913      28-JUL-89      1345        -110
NET_RADTN   SENSIBLE_HEAT_FLUX   SOIL_HEAT_FLUX   DIFFUSE_SOLAR_RADTN_DOWN
---------   ------------------   --------------   ------------------------
-10              4             11.06
44              -3             6.88
106             -26             2.05
178             -65            -3.22
SOLAR_RADTN_DOWN   SOLAR_RADTN_UP   SOLAR_RADTN_NET   SOLAR_RADTN_DOWN_SDEV
----------------   --------------   ---------------   ---------------------
42                10
130                36
228                55
333                73
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
--------------   ------------------------   ------------------------
9
```

7
4
1

SOIL_HEAT_FLUX_10_TO_20CM	HEAT_STORAGE	SOIL_WATER_POTNTL_0_TO_5CM
2		
0		
-2		
-4		

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
23.75	23.75	
23.76	23.76	
23.86	23.86	
24.03	24.03	

SOIL_TEMP_10_TO_20CM	SOIL_TEMP_20_TO_50CM	RAINFALL	BOWEN_RATIO
-.74			
.06			
.32			
.6			

WIND_SPEED	WIND_DIR	WIND_SPEED_MIN	WIND_SPEED_MAX	WIND_SPEED_SDEV
1.47	178			
2.21	204			
2.41	205			
2.66	211			

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
21.52			
23.09			
24.7			
25.86			

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
.219		20.1	
-.0114		20.86	
-.0988		21.36	
-.2326		21.79	

VAPOR_PRESS_HIGH	VAPOR_PRESS_MEAN	VAPOR_PRESS_SDEV	REL_HUMID_LOW
2.259			
2.318			
2.322			
2.342			

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
------------------
21-MAR-91
21-MAR-91
21-MAR-91
21-MAR-91
```

8. Data Organization:

Data Granularity:

These are the point data collected from May 26, 1987 through October 17, 1987, and July 18, 1989 through August 12, 1989. The data values are 30 minute averages of the measured values. Sampling was performed at 30 second intervals.

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 fieldstmosphere 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 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:

None.

10. Errors:

Sources of Error:

Not provided by the Principal Investigator.

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 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, and
- 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. The data have also been checked for an imbalance in the energy equation. Details of these analyses are described in the Surface Flux Baseline 1992 document on FIFE CD-ROM Volume 1.

FIS staff applied a general QA procedure to the data 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 each numerical field in the data table. 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:

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 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:

To obtain ground truth for an experiment like FIFE, it is necessary to know how many surface flux stations are needed to represent a rolling prairie topography of about 15 x 15 km area. The data in this data set can be used to estimate the number of stations needed to represent such a landscape.

Any Other Relevant Information about the Study:

Not available at this revision.

12. Application of the Data Set:

This data set can be used to evaluate the variation in data from the stations which were of similar design and operation, located on slopes with different aspects.

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

\DATA\SUR_FLUX\30_MIN\GRIDxxxx\YyyMmm\ydddgrid.BRL or
\DATA\SUR_FLUX\30_MIN\GRIDxxxx\Yyy\ydddgrid.BRL

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), 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 .BRL for this data set.

17. References:

Satellite/Instrument/Data Processing Documentation.

Gay, L.W. and R.J. Greenberg. 1985. The AEET battery-powered Bowen ratio system. Proc. 17th Conf. Agric. and Forest Meteorol., pp. 181-182., Am. Meteor. Soc., Boston, MA.

Field, R.T., L.J. Fritschen, E.T. Kanemasu, E.A. Smith, J.B. Stewart, S.B. Verma and W.P. Kustas. 1992. Calibration, comparison and correction of net radiometer instruments used during FIFE. J. Geophys. Res. 97(D17):18,681-18,695.

Fritschen, L.J., and J.R. Simpson. 1989. Surface energy and radiation balance systems: General description and improvements. J. Appl. Meteorol. 28:680-689.

Journal Articles and Study Reports.

Baldocchi, D.D., B.B. Hicks, and T.P. Meyers. 1988. Measuring biosphere atmosphere exchanges of biologically related gases with micrometeorological methods. Ecology. 69:1331-1340.

Businger, J.A. 1986. Evaluation of the accuracy with which dry deposition can be measured with current micrometeorological techniques. J. Clim. and Appl. Meteorol. 25:1100-1124.

Fritschen, L.J., P. Qian, E.T. Kanemasu, D. Nie, E.A. Smith, J.B. Stewart, S.B. Verma and M.L. Wesely. 1992. Comparison of Surface flux measurement systems used in FIFE 1989. J. Geophys. Res. 97(D17):18,697-18,713.

Kanemasu, E.T., S.B. Verma, E.A. Smith, L.J. Fritschen, M. Weseley, R.T. Field, W.P. Kustas, H. Weaver, J.B. Stewart, R. Gurney, G. Panin and J.B. Moncrieff. 1992. Surface flux measurements in FIFE: An overview. J. Geophys. Res. 97(DI7) 18,547-18,555.

Nie, D., and E.T. Kanemasu. 1989. Comparison of net radiation on slopes. In: Proc. 19th Conf. Agric. and Forest Meteorol., Charleston, SC, Am. Meteor. Soc., Boston, MA.

Nie, D., E.T. Kanemasu, L.J. Fritschen, H.L. Weaver, E.A. Smith, S.B. Verma, R.T. Field, W.P. Kustas, and J.B. Stewart. 1992. An intercomparison of surface energy flux measurement systems used during FIFE 1987. J. Geophys. Res. 97(D17):18,715-18,724.

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 Distributed Active Archive Center EOSDIS Earth Observing 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 PRT Platinum Resistance Thermometer REBS Radiation and Energy Balance System 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, the 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.

Document Review Date:

September 30, 1996.

Document ID:

ORNL- FIFE_SF30_BRL.

Citation:

Cite this data set as follows:

Fritschen, L. J. 1994. Bowen Ratio Surf[ace]. Flux: Fritschen (FIFE). Data set. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/19. Also published in D. E. Strebel, D. R. Landis, K. F. Huemmrich, and B. W. Meeson (eds.), Collected Data of the First ISLSCP Field Experiment, Vol. 1: Surface Observations and Non-Image Data Sets. CD-ROM. National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland, U.S.A. (available from http://www.daac.ornl.gov).

Document Curator:
DAAC Staff

Document URL:
http://daac.ornl.gov