Surface Radiance Data: UNL (FIFE)

Summary:

The Surface Temperatures, Reflected and Emitted Radiation, and PAR from UNL Data Set contains surface temperatures at different view zenith and azimuth angles, net radiation, incoming and reflected photosynthetically active radiation, incoming and reflected shortwave radiation, and reflected and emitted longwave radiation.

Surface temperatures were measured at a 30 degree view zenith angle with an Everest infrared thermometer (IRT) Model 112C and at approximately a 60 degree view zenith angle with a Scheduler Plant Stress Monitor at 4 view azimuths (predominantly 90 degree increments from the solar azimuth). The Scheduler also measured air temperature, relative humidity, and vapor pressure deficit. Net radiation was measured with a Radiation and Energy Balance Systems (REBS) net radiometer Model Q*3. Incoming shortwave radiation was measured with a horizontally mounted Eppley Precision Pyranometer Model PSP. Reflected shortwave radiation was measured with two (2) Eppley Precision pyranometers Model PSP usually mounted horizontally (at site 966 (2437-PSP) one PSP was mounted horizontally and the other was inclined parallel to the slope). Reflected and emitted longwave radiation were measured with a horizontally mounted Eppley Precision Infrared Radiometer Model PIR.

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1. Data Set Overview:

Data Set Identification:

Surface Radiance Data: UNL (FIFE).
(Surface Temperatures, Reflected and Emitted Radiation, and PAR from UNL).

Data Set Introduction:

The Surface Temperatures, Reflected and Emitted Radiation, and PAR from UNL Data Set contains surface temperatures at different view zenith and azimuth angles, net radiation, incoming and reflected photosynthetically active radiation, incoming and reflected shortwave radiation, and reflected and emitted longwave radiation.

Objective/Purpose:

1. Characterize bi-directional reflectance factor distributions in the solar principal plane for a tall grass prairie.
2. Estimate surface albedo from bi-directional reflectance factor and radiance data.
3. Determine the variability of reflected and emitted fluxes in selected spectral wavebands as a function of topography, vegetative community, and management practice.
4. Determine the influence of plant water status on surface reflectance factors.
5. Determine Sun angle effects on radiation fluxes.

Summary of Parameters:

1987:

Surface temperatures were measured at a 30 degree view zenith angle with an Everest infrared thermometer (IRT) Model 112C and at approximately a 60 degree view zenith angle with a Scheduler Plant Stress Monitor at 4 view azimuths (predominantly 90 degree increments from the solar azimuth). The Scheduler also measured air temperature, relative humidity, and vapor pressure deficit. Net radiation was measured with a Radiation and Energy Balance Systems (REBS) net radiometer Model Q*3. Incoming and reflected shortwave radiation measured with an Eppley Precision Pyranometer Model PSP.

1988:

Surface temperatures were measured at a 30 degree view zenith angle with an Everest infrared thermometer (IRT) Model 112C and at approximately a 60 degree view zenith angle with a Scheduler Plant Stress Monitor at 4 view azimuths (at 90 degree increments predominantly from the solar azimuth). The Scheduler also measured air temperature, relative humidity, and vapor pressure deficit.

Net radiation was measured with two (2) Radiation and Energy Balance Systems (REBS) net radiometers Model Q*3. Incoming and reflected shortwave radiation were measured with two (2) Eppley Precision Pyranometers Model PSP. Incoming and reflected photosynthetically active radiation (PAR) were measured with a LI-COR LI-190SA Quantum sensor.

1989:

Surface temperatures were measured at an approximate 60 degree view zenith angle with a Scheduler Plant Stress Monitor (only at Site 966 (2437-SCN)) at four (4) view azimuths (0, 90, 180, and 270 degrees). The Scheduler also measured air temperature and relative humidity. Net radiation was measured with two (2) Radiation and Energy Balance Systems (REBS) net radiometers Model Q*3 usually mounted horizontally (at site 966 (2437-REB) one REBS was mounted horizontally and the other was inclined parallel to the slope). Incoming shortwave radiation was measured with a horizontally mounted Eppley Precision Pyranometer Model PSP. Reflected shortwave radiation was measured with two (2) Eppley Precision pyranometers Model PSP usually mounted horizontally (at site 966 (2437-PSP) one PSP was mounted horizontally and the other was inclined parallel to the slope). Reflected and emitted longwave radiation were measured with a horizontally mounted Eppley Precision Infrared Radiometer Model PIR.

Discussion:

1987:

A spatial sampling at a variety of sites, as well as within each site, was achieved. A number of plots were identified at the sites varying from 8-27 depending on the site. Measurements were typically coordinated with aircraft and/or satellite overpasses.

The Everest Infrared Thermometer (IRT) Model 112C was mounted on a black painted conduit pole at a height of 2.5 m above the soil surface with a constant view zenith angle of 30 degrees. Measurements were taken at four (4) view azimuths at 90 degree increments predominantly from the solar azimuth angle and occasionally from the satellite view azimuth angle.

The Scheduler Plant Stress Monitor was hand-held at an approximate height of 0.9 m above the soil surface at a view zenith angle of 60 degrees. Measurements were taken at four (4) view azimuths at 90 degree increments predominantly from the solar azimuth angle and occasionally from the satellite view azimuth angle.

A Radiation and Energy Balance Systems (REBS) net radiometer and Eppley Precision Pyranometer Model PSP were mounted on an A-frame made from a black-painted conduit at a height of approximately 1 meter above the soil surface. The PSP was mounted on a rotating platform for measurement of the incoming and reflected shortwave radiation.

1988:

A spatial and temporal sampling at site 811 (4439-PAM) were achieved. Four (4) plots were identified at the site. Measurements were occasionally coordinated with satellite overpasses.

The Everest infrared thermometer (IRT) Model 112C was mounted on a black-painted conduit pole at a height of 2.5 m above the soil surface with a constant view zenith angle of 30 degrees. Measurements were taken at four (4) view azimuths usually in 90 degree increments from the solar azimuth.

The Scheduler Plant Stress Monitor was hand-held at an approximate height of 0.9 m above the soil surface at a view zenith angle of 60 degrees. Measurements were taken at four (4) view azimuths usually in 90 degree increments from the solar azimuth angle.

Two (2) Radiation and Energy Balance Systems (REBS) net radiometers, Eppley Precision Pyranometers Model PSP and LI-COR quantum sensors were mounted on an A-frame made from black-painted conduit at a height of approximately 1 meter above the soil surface. One PSP was mounted facing upward and the other PSP was mounted facing downward to measure incoming and reflected shortwave radiation, respectively. The quantum sensors were mounted the same as the PSPs to measure the incoming and reflected photosynthetically active radiation (PAR).

1989:

A spatial and temporal sampling at sites 906 (2133-REB), 916 (4439-REB), and 966 (2437-REB) were achieved. At sites 906 (2133-REB) and 916 (4439-REB), six (6) plots were identified. One of the 6 plots was a bare soil plot prepared with a weed trimmer that removed the surface vegetation, but left the root systems intact. On days when measurements were not made, the bare soil was covered with a plastic mulch that allowed moisture to penetrate the surface, but hindered the regrowth of the vegetation. Measurements were typically coordinated with aircraft and/or satellite overpasses. At site 966 (2437-REB), sixteen (16) plots were identified. One of these plots was a bare soil plot that was treated in the aforementioned manner.

The Scheduler Plant Stress Monitor was only used at Site 966 (2437-SCN). It was hand-held at an approximate height of 0.9 m above the soil surface at a view zenith angle of 60 degrees. Measurements were taken at two view azimuth angles (180 degree increments from the aspect of the plot).

Two (2) Radiation and Energy Balance Systems (REBS) net radiometers, three (3) Eppley Precision Pyranometers Model PSP, and an Eppley Precision Infrared Radiometer (PIR) were mounted on an A-frame made from black-painted conduit at a height of approximately 1 meter above the soil surface. One PSP was mounted facing upward and the other two PSPs were mounted facing downward to measure the incoming and reflected shortwave radiation, respectively. The PIR was mounted facing downward to measure the reflected and emitted longwave radiation. At sites 906 (2133-REB) and 916 (4439-REB), all of the instruments were mounted horizontally. At site 966 (2437-REB and 2437-PSP), one net radiometer and one downward mounted PSP were inclined parallel to the slope of each plot. The rest of the instruments were mounted horizontally.

Related Data Sets:

- Surface Reflectance Measured with a Mast-borne MMR.
- Surface Reflectance Measured with a Helicopter-borne MMR.
- Leaf Optical Properties from UNL.
- SE-590 Spectroradiometer Reflectance Factors from GSFC.
- SE-590 Reflectance Factors and Radiances from UNL.
- SE-590 Reflectance Factors and Radiances Measured from a Helicopter.
- SE-590 Leaf Level Spectral Observations from GSFC.
- Surface Temperature from UNL.
- Surface Temperature Measured at Multiple Angles.
- Incoming Longwave Radiation Data from UNL.
- Leaf Area Index and PAR Determined from UNL Light Bar Measurements.
- Indirect Leaf Area Index Obtained from the UNL Light Wand.
- Total Leaf Tissue Water Potential.
- Biophysical Properties of Vegetation.
- Vegetation Species and Cover Abundance.
- UNL Topography of Plots information in the GRABBAG (i.e., UNL_Plot.T87, UNL_Plot.T88, and UNL_Plot.T89). (Imagery)

FIS Data Base Table Name:

SURFACE_RADIANCE_UNL_DATA.

2. Investigator(s):

Investigator(s) Name and Title:

Drs. Blaine L. Blad, and E. A. Walter-Shea
University of Nebraska

Title of Investigation:

Measuring and Modeling Near-Surface Reflected and Emitted Radiation Fluxes at the FIFE Site.

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Requested Form of Acknowledgment.

The Surface Temperatures, Reflected and Emitted Radiation and PAR from UNL data were collected by B.L. Blad, E.A. Walter-Shea, C.J. Hays, and M.A. Mesarch of the University of Nebraska, Lincoln.

3. Theory of Measurements:

Definitions:

Thermal radiant energy (**Rb (1 - e) ILWY: sed**) of an emitted component (**e * a * Ts**4**) and a reflected component:

Rb = a * Tirt4 = e * a * Ts**4 + (1 - e) ILW**

where:

e = surface emissivity (unitless)
Ts = surface temperature (K)
ILW = incoming longwave radiation (W/m**2)
a = Stefan-Boltzmann constant (W/m**2/K**4)
Tirt = temperature measurement from infrared thermometer (K)

Net Radiation (**Rn**) is the balance of the shortwave and longwave radiation streams:

Rn = RSW - r * RSW + RLWA - RLWS

where:

RSW = incoming solar radiation
r = reflection coefficient (albedo)
RLWS = outgoing longwave radiation from the surface
RLWA = incoming longwave radiation from atmosphere

Net radiation is the quantity of energy available at Earth's surface to drive processes of photosynthesis, air and soil heating, evaporation, and miscellaneous processes such as respiration. Net radiation varies diurnally, seasonally and spatially. It is positive during the day and reaches its maximum value generally near solar noon. The shortwave component can have a significant effect on the radiation balance.

Vapor pressure deficit (**VPD**) is the difference between saturation vapor pressure and actual vapor pressure.

4. Equipment:

Sensor/Instrument Description:

The Everest infrared thermometer (IRT) Model 112C and Scheduler Plant Stress Monitor measure a temperature that is equal to:

T = (a * Rb)0.25** (Fuchs and Tanner 1966)

where:

a = Stefan-Boltzmann constant
Rb = emitted and reflected radiation
T = temperature measured by IRT

The Everest infrared thermometer (IRT) Model 112C has a spectral band-pass of 8-14 microns. The Model 112C dimensions are 25 cm by 75 mm and it weighs 1 kg. The field-of-view is 15 degrees. Serial number 680 was used in 1987, 1988, and 1989.

The Scheduler Plant Stress Monitor has a spectral band-pass of 8-14 microns. The Scheduler is 18 cm by 22 cm by 19 cm and weighs 3.6 Kg. The field-of-view is 8 degrees. Besides temperature measurements, the scheduler also measures air temperature, relative humidity, and vapor pressure deficit. Serial number 870127 was used for 1987, 1988, and 1989.

The Eppley Precision Spectral Pyranometer (PSP) produces an analog voltage response to scene radiance in the 0.285 - 2.80 micron region. The PSP has a painted cast bronze stand with a white enameled guard disc. In 1987, serial number 25930F3 was used to measure the reflected and incoming shortwave radiation. In 1988, Serial number 26233F3 measured the reflected shortwave radiation and serial number 25930F3 measured the incoming shortwave radiation. In 1989, serial number 26233F3 and serial number 25930F3 measured the reflected shortwave radiation (serial number 25930F3 was inclined parallel to the slope of each plot at site 966 (2437-BBS), otherwise both PSPs were mounted horizontally) and serial number 26234F3 measured the incoming shortwave radiation.

The Eppley Precision Infrared Radiometer (PIR) produces four (4) analog voltage responses that are from: 1) the thermistor embedded in the dome, 2) the thermistor embedded near the thermopile, 3) the thermopile, and 4) the thermopile through a thermistor-battery-resistance circuit. Responses 3 and 4 are in the 4 to 50 micron region. In 1989, serial number 25972F3 measured the reflected and emitted longwave radiation.

The Radiation Energy Balance System (REBS) net radiometer Model Q*3 produces an analog voltage response proportional to the scene radiance. Serial number 86038 or 86042 was used in 1987. Serial number 86038 and serial number 86042 were used in 1988. In 1989, serial number

86042 was always mounted horizontally and serial number 86038 was inclined parallel to the slope of the plot at site 966 (2437-BBS), otherwise it was mounted horizontally.

The LI-COR LI-190SA Quantum sensor measures photosynthetically active radiation (PAR) in the 0.4 to 0.7 micron waveband and produces an analog voltage response proportional to the scene radiance. In 1987, no quantum sensors were used. In 1988, serial number Q10889 was used to measure the incoming PAR, and serial number Q10890 was used to measure the reflected PAR. In 1989, no quantum sensors were used.

Collection Environment:

Ground-based.

Source/Platform:

The Everest infrared thermometer (IRT) Model 112C was mounted on a black conduit pole 2.5 m above the soil surface. The IRT was mounted at a permanent 30-degree view angle.

The Scheduler Plant Stress Monitor was hand-held at an approximate height of 0.9 m and a view zenith angle of 60 degrees.

The Radiation and Energy Balance Systems (REBS) net radiometers, Eppley Precision Pyranometers, LI-COR 190SA Quantum sensors, and Eppley Precision Infrared Radiometer were all mounted on an A-frame. For a description of the instruments mounted in each year, see the *Summary of Parameters Section*. The A-frame was constructed from conduit and painted flat black. The sensor mounting platforms rotated about the center piece of conduit allowing the sensors to be mounted facing upward or downward.

Source/Platform Mission Objectives:

Not applicable.

Key Variables:

Surface temperatures at different view zenith and azimuth angles, net radiation, incoming and reflected photosynthetically active radiation, incoming and reflected shortwave radiation, and reflected and emitted longwave radiation.

Principles of Operation:

The Scheduler Plant Stress Monitor and Everest infrared thermometers Model 112C measure an integrated emitted and reflected radiation value from a target over their specific field-of-view. This radiation is related to the surface temperature by the Stefan-Boltzmann law. For a further description of the basic principles of infrared thermometry, see Fuchs and Tanner (1966). For the specifics of the aforementioned instruments, see the appropriate instruction manual.

The Eppley Precision Spectral Pyranometer is comprised of a circular multi-junction Eppley thermopile of the plated (copper-constant) and wirewound type that is temperature compensated. The thermopile receiver is coated with Parsons' black lacquer (nonwavelength-selective absorption). The PSP has a pair of polished concentric hemispheres of Schott clear optical glass (WG7). The WG7 clear glass is transparent from a wavelength of about 0.285 to 2.8 microns (Eppley instruction manual).

The Eppley Precision Infrared Radiometer (PIR) is a modification of the Eppley Precision Spectral Pyranometer with the glass dome replaced by a silicon hemisphere. A thermistor-battery-resistance circuit has been added to provide compensation for the thermopile temperature (Eppley instruction manual). Two thermistors are embedded, one in the dome and one near the thermopile. The one near the thermopile can be used to temperature correct a direct reading from the thermopile. The two thermistors are also used to provide a temperature correction for differences between the dome and thermopile temperatures. The Eppley PIR is further described in Albrecht and Cox (1977).

The LI-COR LI-190SA quantum sensor is comprised of a silicon photodiode with an enhanced response in the visible wavelength. A visible bandpass interference filter and colored glass filter are mounted in a cosine corrected head. For further information, see the LI-COR radiation sensors instruction manual.

The Radiation Energy Balance Systems (REBS) net radiometer Model Q*3 is designed to measure net radiation. It is comprised of a high output thermopile with 31 junctions of two alloys. The top and bottom thermopile surfaces are painted black and are covered by hemispherical polyethylene windshields that do not require pressurization. For further information, see the REBS net radiometer instruction Manual.

Sensor/Instrument Measurement Geometry:

The Everest infrared thermometer (IRT) Model 112C was mounted on a pole 2.5 m above the soil surface at a constant view zenith angle of 30 degrees. The IRT has a 15-degree field-of-view and viewed an oval spot size with approximate diameters of 0.9 m and 0.7 m and an area of approximately 0.5 m**2.

The Scheduler Plant Stress Monitor was hand-held at an approximate height of 0.9 m and view zenith angle of 60 degrees. The scheduler has a 8-degree field-of-view and viewed an oval spot size with approximate diameters of 0.2 m and 0.6 m and an area of approximately 0.1 m**2.

The Radiation Energy Balance Systems net radiometers, Eppley Precision Spectral Pyranometers and Infrared Radiometers, and LI-COR 190SA quantum sensors were mounted on an A-Frame. The A-frame was constructed of conduit that was painted flat black. The sensors were mounted at an approximate height of 1 meter above the soil surface. The sensor mounting platforms on the A-frame allowed the sensors to be mounted downward or upward facing. All sensors have an actual or near hemispherical field-of-view.

Manufacturer of Sensor/Instrument:

12 Sheffield Ave.
Newport, RI 02840
(401) 847-1020

LI-COR, Inc.
4421 Superior Street
P.O. Box 4425
Lincoln, NB 68504
(402) 467-3576

Radiation and Energy Balance Systems, Inc. (REBS)
P.O. Box 15512
Seattle, WA 98115-0512
(206) 624-7221

Everest Interscience Inc.
P.O. Box 3640
Fullerton, CA 92634-3640
(714) 992-4461

SCHEDULER PLANT STRESS MONITOR:

Original Manufacturer:
Carborundum Company Instrument Technologies
Standard Oil Engineered Materials Company
6180 Cochran Road
P.O. Box 391316
Solon, OH 44139
(216) 349-6887

Current Manufacturer:
Infrared Industries
10 Higgins Drive
Milford, CT 06460
(407) 823-8745

Calibration:

1987:

A post-season calibration was performed on the Radiation Energy Balance System (REBS) net radiometers and Eppley Precision Spectral Pyranometers (PSP) using an Eppley Normal-Incidence Pyrheliometer (NIP) serial number 19791E6. The calibration procedure is described in Iqbal (1983).

A post-season calibration was performed on the Scheduler Plant Stress Monitor. The procedure is the same as for the Everest multiplexed infrared thermometer Model 4000 described in Blad et al., 1990. Daily stability checks were made using an Everest Model 1000 calibration source. Air temperature, relative humidity, and vapor pressure deficit sensors and calculations were not calibrated.

A pre-season adjustment and a post-season calibration were performed on the Everest infrared thermometer (IRT) Model 112C. The calibration procedure is the same as for the Everest multiplexed infrared thermometer Model 4000 described in Blad et al., 1990. Daily stability checks were made using an Everest Model 1000 calibration source. The adjustment was performed by personnel at the USDA - ARS Water Conservation Laboratory in Phoenix, Arizona.

1988:

The 1987 post-season calibration was performed on the Everest infrared thermometer (IRT) Model 112C was assumed valid. Daily stability checks were made using an Everest Model 1000 calibration source.

The 1987 post-season calibration on the Scheduler Plant Stress Monitor was assumed valid. Daily stability checks were made using an Everest Model 1000 calibration source.

The 1987 post-season calibrations performed on the Radiation Energy Balance System (REBS) net radiometers and Eppley Precision Spectral Pyranometers were assumed valid.

A pre-season calibration was performed on the LI-COR 190SA quantum sensors by LI-COR. See the LI-COR radiation instrument manual for specifics.

1989:

A mid-season calibration was performed on the Scheduler Plant Stress Monitor. The procedure is the same as described in Blad et al., 1990 for the Everest multiplexed infrared thermometer Model 4000. Daily stability checks were made using an Everest Model 1000 calibration source. Air temperature, relative humidity, and vapor pressure deficit sensors and calculations were not calibrated.

A pre-season adjustment was performed on the Everest infrared thermometer (IRT) Model 112 by personnel at the USDA-ARS Water Conservation Laboratory in Phoenix, Arizona.

A post-season calibration was performed on the Eppley Precision Spectral Pyranometers (PSP). The calibration was performed using a standard PSP (i.e., originally calibrated by Eppley and never used in the field.) The PSPs were mounted near each other and data were recorded every 5 minutes. A linear regression was performed on these data to obtain the new calibration coefficients.

A pre-season calibration was performed on the Eppley Infrared Radiometer by Eppley. See Eppley's instruction manual for specifics.

A post-season calibration was performed on the Radiation Energy Balance System (REBS) net radiometers by REBS. See REBS instruction manual for specifics.

Specifications:

An attempt was made to calibrate the Eppley Precision Infrared Radiometer (PIR) for differences in the dome thermistor temperature and the thermopile thermistor temperature using the procedure of Albrecht and Cox (1977). Due to equipment and laboratory limitations, the calibration constant obtained was erroneous. Smith (1988) suggested that a calibration constant of k=5 (used in equations 6 and 7, see the *Formulae Section*) for this correction is acceptable.

The polyethylene windshields on the Radiation Energy Balance System (REBS) net radiometers need to be cleaned periodically and replaced every year or when scratches or cloudiness was noticed. Desiccant in the support arm needs to be checked weekly to prevent condensation on the inside of the dome. Condensation and/or damage to the windshield will change the calibration results.

The Eppley Precision Spectral Pyranometers and Infrared Radiometer hemispheres also need to be cleaned periodically. These instruments also have desiccant that should be checked. Changes to the hemispheres will affect the calibration results.

The LI-COR LI-190SA quantum sensor must also be kept clean to maintain calibration results.

Tolerance:

The Scheduler Plant Stress Monitor instruction manual specifications are:

- Surface Temperature +/- 1 degree F
- Air Temperature +/- 0.5 degree F
- Relative Humidity +/- 5%

When the calibration derived coefficients are applied to the calibration data set (i.e., not an independent data set) comparisons of the corrected instrument reading to the blackbody source temperature show that the mean bias errors ranged from 0.0 to 0.1 degree C and the mean relative errors ranged from -1.0 to 0.7 % over the 3 years.

The Everest infrared thermometer Model 112C specifications are an accuracy of +/- 0.5 degree C and a resolution of 0.1 degree C.

When the calibration-derived coefficients are applied to the calibration data set (i.e., not an independent data set) or after the instrument was adjusted, comparisons of the corrected instrument reading to the blackbody source temperature show that the mean bias errors ranged from 0.4 to 0.0 degree C and the mean relative errors ranged from -0.2 to 0.2 % over the 3 years.

The Eppley Precision Spectral Pyranometers output is accurate to 1% over a -20 to 40 degree C range (Tanner 1990).

The Eppley Precision Infrared Radiometers accuracy is theoretically 5 % (Albrecht and Cox 1977).

The LI-COR 190SA Quantum sensor absolute calibration is within +/- 5% (usually with +/- 3% under most sky conditions. It is cosine corrected up to 80 degree angle of incidence.

The Radiation Energy Balance Systems net radiometer Model Q*3 accuracy is +/- 5% (Fritschen 1991).

Frequency of Calibration:

1987:

A post-season calibration was performed on the Radiation Energy Balance System (REBS) net radiometers and Eppley Precision Spectral Pyranometers (PSP) using an Eppley Normal-Incidence Pyrheliometer (NIP) serial number 19791E6.

A post-season calibration was performed on the Scheduler Plant Stress Monitor. Daily stability checks were made using an Everest Model 1000 calibration source. Air temperature, relative humidity, and vapor pressure deficit sensors and calculations were not calibrated.

A pre-season adjustment and a post-season calibration were performed on the Everest infrared thermometer (IRT) Model 112C. Daily stability checks were made using an Everest Model 1000 calibration source.

1988:

Daily stability checks were made on the Scheduler Plant Stress Monitor using an Everest Model 1000 calibration source.

Daily stability checks were made on the Everest infrared thermometer (IRT) Model 112 using an Everest Model 1000 calibration source.

No calibrations were performed on the Radiation Energy Balance System (REBS) net radiometers and Eppley Precision Spectral Pyranometers.

A pre-season calibration was performed on the LI-COR 190SA quantum sensors by LI-COR.

1989:

A mid-season calibration was performed on the Scheduler Plant Stress Monitor. Daily stability checks were made using an Everest Model 1000 calibration source. Air temperature, relative humidity and vapor pressure deficit sensors, and calculations were not calibrated.

A pre-season calibration/adjustment was performed on the Everest infrared thermometer (IRT) Model 112C. Daily stability checks were made using an Everest Model 1000 calibration source.

A post-season calibration was performed on the Eppley Precision Spectral Pyranometers (PSP).

A pre-season calibration was performed on the Eppley Infrared Radiometer by Eppley.

A post-season calibration was performed on the Radiation Energy Balance Systems (REBS) net radiometers by REBS.

Other Calibration Information:

The calibration coefficients for the Eppley precision spectral pyranometers were always within +/- 3 % of the original coefficients. Thus, the original coefficients were used for data reduction in 1987, 1988, and 1989. In 1987, the manufacturer's coefficients from 1987 were used for the REBS net radiometers rather than the post-season coefficients. The post-season calibration coefficients were used in 1988. In 1989, the post-season calibration coefficients were used.

When the calibration derived coefficients for the Everest infrared thermometer Model 112c and Scheduler Plant Stress Monitor are applied to the calibration data set (i.e., not an independent data set) comparisons of the corrected instrument reading to the blackbody source temperature show that the mean bias errors ranged from -0.2 to 0.1 degree C and the mean relative errors ranged from -1.0 to 3.9 % over the 3 years for the three different instruments. When calibration-derived coefficients were not applied to the same data set comparisons to the blackbody source show that the mean bias errors ranged from -0.8 to 1.0 degree C and the mean relative errors ranged from -3.2 to 23.0 %.

Calibration Coefficients

1987:

- Everest Infrared Thermometer Model 112C
  Serial Number 680
  a = 1.1754 degree C
  b = 0.9808
- Scheduler Plant Stress Monitor
  Serial Number 870127
  a = 0.1920 degree C
  b = 0.9960
- Eppley Precision Spectral Pyranometer Model PSP
  Serial Number 25930F3
  101.317 W/m**2/mv
- Radiation Energy Balance Systems net radiometers Model Q*3
  Serial Number 86042; 21.5 W/m**2/mv
  Serial Number 86038; 21.5 W/m**2/mv

1988:

- Everest Infrared Thermometer Model 112c
  Serial Number 680
  a = 1.1754 degree C
  b = 0.9808
- Scheduler Plant Stress Monitor
  Serial Number 870127
  a = 0.1920 degree C
  b = 0.9960
- Eppley Precision Spectral Pyranometer Model PSP
  Serial Number 25930F3; 101.317 W/m**2/mv
  Serial Number 26233F3; 114.42 W/m**2/mv
- Radiation Energy Balance Systems net radiometers Model Q*3
  Serial Number 86042; 22.64 W/m**2/mv
  Serial Number 86038; 26.14 W/m**2/mv
- LI-COR LI-190SA Quantum Sensors
  Serial Number Q10890; 294.603 uE/s/m**2/mv
  Serial Number Q10889; 254.712 uE/s/m**2/mv

1989:

- Scheduler Plant Stress Monitor
  Serial Number 870127
  a = -0.3005 degree C
  b = 1.0036
- Eppley Precision Spectral Pyranometer Model PSP
  Serial Number 25930F3; 101.317 W/m**2/mv
  Serial Number 26233F3; 114.42 W/m**2/mv
  Serial Number 26234F3; 113.40 W/m**2/mv
- Radiation Energy Balance Systems net radiometers Model Q*3
  Serial Number 86042; 24.0 W/m**2/mv
  Serial Number 86038; 27.9 W/m**2/mv
- Eppley Precision Infrared Radiometer Model PIR
  Serial Number 25972F3
  n = 220.26
  k = 5.0

5. Data Acquisition Methods:

1987:

The Everest infrared thermometer (IRT) Model 112C was mounted at a constant view zenith angle of 30 degrees at a height of 2.5 m above the soil surface on a staff constructed of conduit painted flat black. The IRT was checked against the Everest Calibration Source Model 1000. The staff was then positioned at the edge of the plot at the desired view azimuth angle (i.e., 90 degree increments from the solar or satellite view azimuth angle). The IRT viewed the center of the plot at each view azimuth angle. One measurement was recorded at the view azimuth angle. The staff was then moved to the next view azimuth angle (90 degrees from the prior view azimuth angle) and a measurement was recorded. This procedure was repeated for a total of 12 measurements (i.e., 3 replications at 4 view azimuth angles). The staff was then moved to the next plot and the above procedure repeated until the end of the measurement period. At the end of the measurement period, the IRT was checked against the Everest Calibration Source.

The Scheduler Plant Stress Monitor was hand-held at an approximate view zenith angle of 60 degrees at an approximate height of 0.9 m above the soil surface. The same procedure was followed as with the Everest infrared thermometer (IRT) Model 112C except that at each view azimuth angle the mean and standard deviation of three measurements of the surface temperature were recorded. Only the means were recorded for air temperature, relative humidity, and vapor pressure deficit.

An Eppley Precision Spectral Pyranometer Model PSP and a Radiation Energy Balance System net radiometer were mounted approximately 1 meter above the soil surface on an A-frame constructed from conduit painted flat black. The A-frame was positioned within the plot and aligned normal to the solar principal plane with the net radiometer viewing the center of the plot. Measurements from the net radiometer and the PSP mounted upright were recorded. The PSP was inverted and a measurement was recorded with the PSP viewing the center of the plot. The A-frame was then moved into the next plot. This procedure was then repeated until the end of the measurement period.

1988:

The Everest infrared thermometer (IRT) Model 112C was mounted on 2.5 meter mast. Staff followed the same procedure as in 1987 except that three measurements were recorded at each view azimuth angle before moving to the next view azimuth angle. The same number of measurements were taken, but this procedure minimized the traffic around the plot (i.e., only one trip around the plot rather then the three made in 1987).

The Scheduler Plant Stress Monitor also followed the same procedure as described in 1987, except that three separate measurements of surface temperature relative humidity and vapor pressure deficit were made at each view zenith angle (in 1987, these three measurements were averaged).

The number of sensors on the A-frame was changed but the same procedure as in 1987 was followed. The A-frame had two Radiation Energy Balance System net radiometers, two Eppley Precision Spectral Pyranometers (PSPs) and two LI-COR 190SA Quantum sensors. One of the PSP and Quantum sensors was mounted facing upright and the others were inverted.

1989:

The Scheduler Plant Stress Monitor was only in operation at site 966 (2437-SCN) on June 15 and August 13. Measurements were made at two view azimuth angles in the aspect plane of the plot.

The number of replications at each view azimuth angle varied from 1 to 3. Only measurements of surface temperature, air temperature, and relative humidity were recorded. Unless otherwise noted, the same procedure as in 1987 and 1988 was followed.

The A-frame had two Radiation Energy Balance System net radiometers, three Eppley Precision Spectral Pyranometers (PSPs), and an Eppley Precision Infrared Radiometer (PIR) mounted on it. Two of the Eppley PSPs and the PIR sensor were inverted. One to six replications were recorded at various locations within each plot. At site 966 (2437-BBS), one net radiometer and inverted PSP were inclined parallel to the slope of the plot. The other instruments were mounted horizontally. Also at site 966 (2437-REB), the A-frame was aligned normal to the aspect of the plot. At plot 999, the A-frame was aligned in a north-south plane. At sites 906 (2133-REB) and 916 (4439-REB), all of the sensors were mounted horizontally and the A-frame was aligned normal to the solar principal plane. Unless otherwise noted, the same procedure as in 1987 and 1988 was followed.

All view zenith angles were measured with respect to gravity not in relation to the slope of the plot.

6. Observations:

Data Notes:

Not available.

Field Notes:

1987:

The Everest infrared thermometer (IRT) Model 112C, Scheduler Plant Stress Monitor and A-frame instruments (Eppley Precision Spectral Pyranometer and Radiation Energy Balance System net radiometer) were used on the following dates and approximate times unless noted below.

- May 30
  - Station 18 (sitegrid 4439) clouds blocking or near sun for most of the measurement period: 1340-1500 GMT. NO IRT and SCHEDULER DATA.
  - Station 28 (sitegrid 6943) clouds blocking or near sun for most of the measurement period: 1540-1635 GMT. NO IRT and SCHEDULER DATA.
- May 31
  - Station 18 (sitegrid 4439) clear skies until middle of first measurement period, then cirrus near the sun, during second measurement period cirrus near or blocking the sun, during third measurement period cirrus blocking the sun, measurement periods: 1330-1440, 1440-1500, 1800-1905 GMT. NO IRT and SCHEDULER DATA.
  - Station 28 (sitegrid 6943) cirrus near or blocking the sun measurement period: 1540-1620 GMT. NO IRT and SCHEDULER DATA.

- June 1
    - Station 28 (sitegrid 6943 hazy skies, measurement period: 1500-1600 GMT.
    - Station 26 (sitegrid 8739) cumulus occasionally blocking sun and hazy skies for first measurement period, cumulus and cirrus occasionally blocking sun during second measurement period, measurement periods: 1700-1740, 2030-2055 GMT. NO IRT and SCHEDULER DATA.
- June 3
    - Station 40 (sitegrid 1246) clear skies, measurement period: 2005-2100 GMT.
- June 4
    - Station 8 (sitegrid 3129) clear skies, measurement periods: 1340-1420, 1440-1520, 1540-1615, 1805-1900, 1950-2050, 2050-2150 GMT.
- June 5
    - Station 18 (sitegrid 4439) clear skies, measurement periods: 1530-1735, 1745-1830 GMT.
    - Station 32 (sitegrid 4268) clear skies, measurement period: 2030-2120 GMT.
- June 6
    - Station 26 (sitegrid 8739) clear skies, measurement period: 1715-1800 GMT.
    - Station 5 (sitegrid 2123) slight haze, measurement period: 2110-2140 GMT.
- June 16
    - Station 42 (sitegrid 1445) no notes. NO IRT and SCHEDULER DATA.
- June 26
    - Station 18 (sitegrid 4439) clear skies, measurement periods: 1505-1615, 1720-1755, 1805-1840, 1845-1915 GMT. NO IRT DATA for first measurement period.
    - Station 26 (sitegrid 8739) clear skies then clouds moved in, measurement period: 2020-2040 GMT.
- June 27
    - Station 26 (sitegrid 8739) clouds moved in measurements aborted, measurement period: 1745-1755 GMT. NO A-FRAME DATA.
- June 28
    - Station 32 (sitegrid 4268) clear skies, measurement period: 1955-2105 GMT. NO SCHEDULER DATA.
- July 1
    - Station 26 (sitegrid 8739) cumulus, measurement periods: 1520-1600, 1720-1800 GMT.
- July 6
    - Station 5 (sitegrid 2123) increasing haze measurements aborted, measurement periods: 1535-1515, 1610-1705, 1750-1810 GMT.
- July 10
    - Station 28 (sitegrid 6943) variable haze, measurement periods: 1400-1440, 1440-1520 GMT.
- July 11
    - Station 18 (sitegrid 4439) slight haze, measurement periods: 1415-1520, 1545-1610 GMT.
    - Station 42 (sitegrid 1445) clear skies, measurement period: 1755-1810 GMT.
    - Station 40 (sitegrid 1246) some haze and cirrus, measurement period 2005-2050 GMT.

- July 14
    - Station 42 (sitegrid 1445) some cirrus, measurement period: 1545-1710 GMT.
    - Station 5 (sitegrid 2123) clear skies, measurement period: 2020-2105 GMT. NO IRT and SCHEDULER DATA.
- July 15
    - Station 170 (sitegrid 0929-BBM) clear skies, measurement period 1710-2115 GMT. NO IRT DATA.
- Aug. 7
    - Station 18 (sitegrid 4439) slight haze, measurement period: 1725-1825 GMT. NO IRT DATA.
    - Station 28 (sitegrid 6943) slight haze, measurement period: 2015-2100 GMT. NO IRT DATA.
- Aug. 10
    - Station 32 (sitegrid 4268) measurements aborted due to cirrus, measurement period: 1410-1435 GMT.
    - Station 26 (sitegrid 8739) slight haze, measurement period: 1735-1815 GMT.
    - Station 32 (sitegrid 4268) cumulus, very dry conditions, measurement period: 2050-2205 GMT.
- Aug. 11
    - Station 40 (sitegrid 1246) clear skies, measurement period: 1350-1435 GMT.
    - Station 42 (sitegrid 1445) slight haze, measurement period: 1725-1810 GMT.
- Aug. 15
    - Station 18 (sitegrid 4439) clear skies, measurement periods: 1440-1530, 1620-1720 GMT.
    - Station 28 (sitegrid 6943) clear skies, measurement periods: 1845-1920, 2005-2050 GMT.
- Aug. 16
    - Station 26 (sitegrid 8739) slight haze, measurement period: 1615-1655 GMT.
    - Station 29 (sitegrid 0847) clear skies, measurement period: 2010-2050 GMT.
- Aug. 17
    - Station 18 (sitegrid 4439) clear skies, measurement period: 1715-1845 GMT.
    - Station 32 (sitegrid 4268) clear skies, measurement period: 2015-2100 GMT.
- Aug. 19
    - Station 170 (sitegrid 0939) measurements aborted due to clouds, measurement periods: 1625-1705, 1945-2030 GMT.
- Aug. 20
    - Station 29 (sitegrid 0847) clear skies, measurement period: 1350-1435 GMT.
    - Station 42 (sitegrid 1445) clear skies, measurement periods: 1550-1635, 1715-1800 GMT.
    - Station 40 (sitegrid 1246) measurements aborted due to clouds, measurement period: 2110-2145 GMT.
- Oct. 6
    - Station 26 (sitegrid 8739) clear skies, measurement period: 1800-1835 GMT.
- Oct. 7
    - Station 18 (sitegrid 4439) cirrus and haze, measurement periods: 1725-1755, 2045-2155 GMT.

- Oct. 9
    - Station 40 (sitegrid 1246) cumulus and cirrus, measurement period 2015-2120 GMT.
- Oct. 11
    - Station 29 (sitegrid 0847) clouds on horizon, measurement period 1515-1555 GMT.
    - Station 42 (sitegrid 1445) clear skies, measurement period: 2000-2045 GMT.
- Oct. 12
    - Station 28 (sitegrid 6943) clear skies, contrails, measurement period 1445-1525 GMT.
    - Station 40 (sitegrid 1246) cirrus and contrails, measurement period 1800-1840 GMT.
    - Station 18 (sitegrid 4439) cirrus, measurement period: 2120-2150 GMT.
- Oct. 13
    - Station 32 (sitegrid 4268) cirrus, measurement period: 1425-1520 GMT.
    - Station 18 (sitegrid 4439) cirrus, measurement period: 1735-1800 GMT.

1988 (all data collected at Station 811 (sitegrid 4439)):

The Everest infrared thermometer (IRT) Model 112C, Scheduler Plant Stress Monitor and A-frame instruments (Eppley Precision Spectral Pyranometers, Radiation Energy Balance System net radiometers and LI-COR 190SA Quantum sensors) were used on the following dates and approximate time unless noted below.

- May 24 Hazy skies, measurement period: 1825-1925 GMT. NO SCHEDULER DATA.
- May 25 Haze near end of measurements, measurement period: 1805-1900 GMT. NO SCHEDULER DATA.
- May 27 Clear skies during the first two measurement periods, hazy skies for the last three measurement periods, measurement periods: 1505-1550, 1620-1705, 1800-1845, 1910-2015, and 2045-2120 GMT. NO SCHEDULER DATA.
- June 28 Clear skies, measurement period: 1530-1635 GMT.
- July 12 Cumulus developing near sun at end of measurement period: 1500-1550 GMT.
- July 13 Clear skies, measurement periods: 1545-1640, 1745-1840, 1920- 2010, 2110-2200 GMT.
- Aug. 11 Clear skies for first two measurement periods, cumulus developing during the last 3 measurement periods, cumulus interfering with the sun during the last measurement period, measurement periods: 1415-1510, 1540-1630, 1820-1930, 2020-2100, 2130-2215 GMT.

1989:

The A-frame instruments (Eppley Precision Spectral Pyranometers and Precision Infrared Radiometer and Radiation Energy Balance Systems net radiometers) were used on the following dates and approximate times. The Scheduler Plant Stress Monitor was only used on June 15, July 14, and August 8.

- June 15 Station 966 (sitegrid 2437) Few cumulus clouds near sun for first measurement period then clear skies, measurement periods: 1500- 1600, 1730-1930, and 2100-2230 GMT.
- July 14 Station 966(2437-BBS) Clear skies for first measurement period, cumulus aborted second measurement period, measurement periods: 1430-1530 and 1600-1620 GMT.
- July 26 Station 916 (sitegrid 4439 Few clouds on horizon, measurement periods: 1400-1425 and 1425-1455 GMT.
- July 27 Station 916 (sitegrid 4439) Cumulus clouds, measurement period: 1430-1530 GMT.
- July 28 Station 916 (sitegrid 4439) Clear skies except for cumulus during last measurement period, measurement periods: 1400-1430, 1500-1530, 1630-1715, 1800-1900 GMT.
- Aug. 4 Station 916 (sitegrid 4439) Clear skies measurement periods: 1400-1500, 1700-1800, 1930-2000 GMT.
- Aug. 6 Station 906 (sitegrid 2133) Clear skies, measurement periods: 1430-1500, 1600-1630, 1800-1840, 1930-2000 and 2045-2100 GMT.
- Aug. 7 Station 906 (sitegrid 2133) Cumulus during first measurement period, the clear skies, measurement periods: 1730-1800 and 1930-2000 GMT.
- Aug. 8 Station 916 (sitegrid 4439) Clear skies, measurement periods: 1415-1510, 1620-1745, 2010-2030 and 2110-2135 GMT.
- Aug. 9 Station 966 (sitegrid 2437) Clear skies for first measurement period, then cumulus, measurement periods: 1530-1630 and 1730-1840 GMT.
- Aug. 11 Station 916 (sitegrid 4439) Lots of cumulus clouds, measurement period 2150-2230 GMT.

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 14 locations within the FIFE study area.

SITEGRID	STN	NORTHING	EASTING	LATITUDE	LONGITUDE	ELEV
0847-IRN	29	4332344	714439	39 06 57	-96 31 11	418
1246-IRN	40	4331666	714212	39 06 35	-96 31 21	365
1445-PSP	42	4331160	714090	39 06 19	-96 31 27	400
1916-IRN	70	4330296	708263	39 05 56	-96 35 30	340
2123-IRN	5	4329866	709506	39 05 41	-96 34 39	405
2133-REB	906	4329726	711604	39 05 34	-96 33 12	443

2437-REB	966	4329150	712375	39 05 15	-96 32 41	
3129-IRN	8	4327702	710711	39 04 30	-96 33 51	430
4268-IRN	32	4325626	718579	39 03 15	-96 28 27	445
4439-IRN	18	4325218	712792	39 03 07	-96 32 28	445
4439-REB	811	4325219	712795	39 03 07	-96 32 27	445
4439-REB	916	4325193	712773	39 03 06	-96 32 28	443
6943-IRN	28	4320147	713500	39 00 22	-96 32 04	415
8739-IRN	26	4316699	712845	38 58 31	-96 32 35	442

SITEGRID	**SLOPE**	**ASPECT**
0847-IRN		
1246-IRN		
1445-PSP		
1916-IRN		
2123-IEN		
2133-REB	1	TOP
2437-REB		
3129-IRN		
4268-IRN		
4439-IRN		
4439-REB	2	N
4439-REB	2	N
6943-IRN		
8739-IRN		

In 1987 and 1988 measurement plots generally encircled the AMS station located at that site. In 1989 measurement plots were located northeast of the Wind Aligned Blob (WAB) site (Sellers et al., 1989). Topography files containing the northing and easting of the plots at each station, except for station 18 (SITEGRID_ID=4439-IRN) in 1987 and station 966 (SITEGRID_ID=2437-REB) in 1989, are available in the GRABBAG section of FIFE CD-ROM Volume 1 in the UNL directory, in files UNL_PLOT.T87, UNL_PLOT.T88, UNL_PLOT.T89. These files also include the slope, aspect, soil depth, species and vegetative height of the plots.

Spatial Coverage Map:

Not available.

Spatial Resolution:

The surface area viewed by the Everest Infrared Thermometer Model 112C was an oval with diameters of approximately 0.7 m and 0.9 m, and an approximate area of 0.5 [m^2]. The surface area viewed by the Scheduler Plant Stress Monitor was an oval with diameters of approximately 0.2 meters and 0.6 meters and an approximate area of 0.1 [m^2]. The sensors on the A-frame (Radiation Energy Balance net radiometers, Eppley Precision Spectral Pyranometers and Precision Infrared Radiometer, and LI-COR 190SA Quantum sensors) have an actual or near hemispherical field-of-view. The plot size was approximately 3 meters x 3 meters.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

Measurements were made from May 30, 1987 through August 11, 1989. During this period measurements were collected on 49 days during the growing season. The dates of data collection follow:

```
                OBS_DATE             OBS_DATE             OBS_DATE
---------            ---------            ---------
30-MAY-87            10-AUG-87            28-JUN-88
31-MAY-87            11-AUG-87            12-JUL-88
01-JUN-87            15-AUG-87            13-JUL-88
03-JUN-87            16-AUG-87            11-AUG-88
04-JUN-87            17-AUG-87            15-JUN-89
05-JUN-87            19-AUG-87            14-JUL-89
06-JUN-87            20-AUG-87            26-JUL-89
16-JUN-87            06-OCT-87            27-JUL-89
26-JUN-87            07-OCT-87            28-JUL-89
01-JUL-87            09-OCT-87            04-AUG-89
06-JUL-87            11-OCT-87            06-AUG-89
10-JUL-87            12-OCT-87            07-AUG-89
11-JUL-87            13-OCT-87            08-AUG-89
14-JUL-87            24-MAY-88            09-AUG-89
15-JUL-87            25-MAY-88            10-AUG-89
07-AUG-87            27-MAY-88            11-AUG-89
```

In 1987 and 1988, measurements of all the plots at a site required 1 hour.

In 1987, measurements at a site were usually coordinated with aircraft and satellite overpasses.

In 1988, measurements at a site were occasionally coordinated with satellite overpasses.

In 1989, measurements on all the plot at sites 906 (2133-REB) and 916 (4439-REB) required 30 minutes or less and were coordinated with aircraft and satellite overpasses. Measurements of all the plots at site 966 (2437-REB and 2437-SCN) required 2 to 3 hours.

The measurement time ranged from 1351 to 2200 GMT. Measurements were not continuously made over this range, but were in discrete measurement periods depending on the number of plots in a site and coordination with aircraft and satellite overpasses.

In 1987, data were generally obtained at various sites during a day, hence a lot of time was spent moving and resetting equipment.

In 1988, data were obtained at site 811 (4439-REB). A maximum of five (5) discrete measurement periods throughout the day were obtained.

In 1989, data were obtained at only one site per day. A maximum of five (5) discrete measurement periods throughout the day were obtained.

Temporal Coverage Map:

Not available.

Temporal Resolution:

The optimum time interval between plot measurements was approximately 5 minutes. The typical time interval between plots was approximately 10 minutes. The time interval depended on the distance between the plots, the terrain, and sky conditions.

Data Characteristics:

The SQL definition for this table is found in the SURF_RAD.TDF file located on the 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).		
PLOT_NUM The sample plot number at the FIFE site. Plot 999 is a bare soil plot.		
INSTR_ID The type of instrument used to collect the data.	#	
SLOPE For plots on a hillside, the slope of the plot		[degrees]
ASPECT For plots on a hillside, the aspect direction of the plot, 0 is North, 90 is East		[degrees from North]
VIEW_AZIM_ANG The direction of the observation. from North]		[degrees
SHORTWAVE_RADTN_DOWN The downward (incoming) shortwave radiation (0.285-2.800 microns).		[Watts] [meter^-2]
SHORTWAVE_RADTN_REFL_1 The reflected shortwave radiation (0.285-2.800 microns). This sensor always has a nadir view.		[Watts] [meter^-2]
SHORTWAVE_RADTN_REFL_2 The reflected shortwave radiation (0.285-2.800 microns). For hill side plots this sensor views perpendicular to the slope of the plot.		[Watts] [meter^-2]
ALBEDO_1 The albedo calculated as the ratio of reflected to downwelling shortwave radiation from the nadir viewing instruments.		

ALBEDO_2 The albedo calculated as the ratio of reflected to downwelling shortwave radiation. For hill side plots the reflected radiation is from the sensor viewing perpendicular to the slope of the plot.	
NET_RADTN_1 The net radiation.	[Watts] [meter^-2]
NET_RADTN_2 The net radiation, from a second net radiometer, if present.	[Watts] [meter^-2]
IR_TEMP The infrared temperature (8.0-14.0 microns) of the vegetation canopy.	[degrees Celsius]
SURFACE_TEMP The plant temperature measured by the Scheduler Plant Stress Monitor.	[degrees Celsius]
SURFACE_TEMP_SDEV The standard deviation of the uncorrected surface temperature.	[degrees Celsius]
AIR_TEMP The air temperature.	[degrees Celsius]
REL_HUMID The percent relative humidity.	[percent]
VAPOR_PRESS_DEFICIT The vapor pressure deficit.	[kiloPascals]
EMIT_LONGWAVE_RADTN_1 The emitted longwave radiation (4 to 50 microns) from a direct reading of the thermopile.	[Watts] [meter^-2]

EMIT_LONGWAVE_RADTN_2 The emitted longwave radiation (4 to 50 microns) from a thermopile reading through the thermistor-battery-resistance circuit.		[Watts] [meter^-2]
THERMOPILE_CASE_TEMP The case temperature of the Eppley Precision Infrared Radiometer.		[degrees Celsius]
THERMOPILE_DOME_TEMP The dome temperature of the Eppley Precision Infrared Radiometer.		[degrees Celsius]
PAR_DOWN The downwelling photosynthetically active radiation (0.4 to 0.7 microns). [meter^-2]		[micro Einsteins] [second^-1]
PAR_REFL The reflected photosynthetically active radiation (0.4 to 0.7 microns). [meter^-2]		[micro Einsteins] [second^-1]
FRACTION_REFL_PAR The fraction photosynthetically active radiation (PAR) (0.4 to 0.7 microns) reflected from the surface, calculated as the ratio of reflected to downwelling PAR.		
FIFE_DATA_CRTFCN_CODE The FIFE Certification Code for the data, in the following format: CPI (Certified by PI), CPI-??? (CPI - questionable data).	*	
LAST_REVISION_DATE data, in the format (DD-mmm-YY).		

Footnotes:

Decode the INSTR_ID field as follows:

- IRT 112 = Everest Infrared Thermometer Model 112c
- PSP = Eppley Precision Pyranometer Model PSP
- REBS = Radiation and Energy Balance Systems net radiometer
- SCHED = Scheduler Plant Stress Monitor

Decode the FIFE_DATA_CRTFCN_CODE field as follows:

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 are "merged" from two separate receiving stations to eliminate transmission errors. CPI-??? Investigator thinks data item may be questionable.

Sample Data Record:

```
     SITEGRID   STATION_ID   OBS_DATE     OBS_TIME   PLOT_NUM   INSTR_ID
---------  ----------   ---------   ----------  ---------- ------------
6943-PSP       28       30-MAY-87      1554        1          PSP
4439-PSP       18       31-MAY-87      1455        3          PSP
8739-PSP       26       01-JUN-87      1708        1          PSP
1246-SCN       40       03-JUN-87      2023        1          SCHED
3129-SCN        8       04-JUN-87      1490        3          SCHED
      OBS_DIR    SHORTWAVE_RADTN_DOWN   SHORTWAVE_RADTN_REFL   ALBEDO   NET_RADTN
----------  --------------------   --------------------   -------  ----------
950                   160              .168      456.75
626.01                133.64           .213      399.58
1046.74                182.93           .175      693.15
244.7
190.7
     IR_TEMP     SURFACE_TEMP   SURFACE_TEMP_SDEV   AIR_TEMP    REL_HUMID
----------  ------------   -----------------   ----------  ----------
25.3             .53            24.8         30
21.8             .05            23           43
     VAPOR_PRESS_DEFICIT   FIFE_DATA_CRTFCN_CODE   LAST_REVISION_DATE
-------------------   ---------------------   ------------------
CPI                08-MAR-89
CPI                08-MAR-89
CPI                08-MAR-89
2.17                   CPI                09-MAR-89
1.58                   CPI                09-MAR-89
```

8. Data Organization:

Data Granularity:

These data were collected at the following 14 locations within the FIFE study area. The plot size was approximately 3 m x 3 m. The typical time interval between plots was approximately 10 minutes. The time interval depended on the distance between the plots, the terrain, and sky conditions.

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 begins 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, path and name of the document that describes the data in this file, and name of principal investigator for these data. 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_ID)). Record 4 Path and filename of the previous date, and path and filename of the next date. (Path and filenames for files of the same data set taken at the same site for the previous and next date.) Record 5 Column names for the data within the file, delimited by commas. Record 6 Data records begin.

Each field represents one of the attributes listed in the chart in the *Data Characteristics Section* and described in detail in the TDF file. These fields are in the same order as in the chart.

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

EPPLEY PRECISION SPECTRAL PYRANOMETER MODEL PSP

1. E = V * CC

where:

E = shortwave radiation (W/m**2)
V = voltage (mv)
CC = calibration coefficient (W/m**2/mv)

2Y. Albedo = Erefl / Einc

where:

Erefl = reflected shortwave radiation (W/m**2)
Einc = incoming shortwave radiation (W/m**2)

RADIATION ENERGY BALANCE SYSTEM NET RADIOMETER MODEL Q*3

3Y. E = V * CC

where:

E = net radiation (W/m**2)
V = voltage (mv)
CC = Calibration coefficient (W/m**2/mv)

LI-COR LI-190SA QUANTUM SENSORS

4Y. E = V * CC

where:

E = photosynthetically active radiation (uE/s/m**2)
V = voltage (mv)
CC = calibration coefficient (uE/s/m**2/mv)

5. RATIO = Erefl / Einc

where:

RATIO = ratio of reflected to incoming photosynthetically active radiation
Erefl = reflected photosynthetically active radiation (uE/s/m**2)
Einc = incoming photosynthetically active radiation (uE/s/m**2)

EPPLEY PRECISION INFRARED RADIOMETER MODEL PIR

6. E = n * Vtherm + a * Ttherm4 - k * a (Tdome**4 - Ttherm**4)**

where:

n = calibration coefficient (W/m**2/mv)
k = calibration coefficient (unitless)
Vtherm = voltage from direct thermopile output (mv)
Tdome = temperature of thermistor on the dome (K)
Ttherm = temperature of the thermistor near the thermopile (K)
a = Stephen-Boltzmann constant (W/m**2/K**4)

7. E = n * Vbatt - k * a (Tdome4 - Ttherm**4)**

where:

n = calibration coefficient (W/m**2/mv)
k = calibration coefficient (unitless)
Vbatt = voltage from thermistor-battery-resistance circuit (mv)
Tdome = temperature of thermistor on the dome (K)
Ttherm = temperature of the thermistor near the thermopile (K)
a = Stephen-Boltzmann constant (W/m**2/K**4)

SCHEDULAR PLANT STRESS MONITOR, EVEREST INFRARED THERMOMETERS MODEL 112C.

8. Tirtc = a + b * Tirt

where:

Tirtc = calibration corrected temperature measurement (K);
a = calibration coefficient (K);
b = calibration coefficient (unitless)
Tirt = temperature measurement from one of the three instruments (K);

9. Ts = {a * (Tirtc + 273.16)4 + (1 - e) * ILWY / (e * a)}**.25 - 273.**

where:

e = surface emissivity (unitless)
a = Stefan-Boltzmann constant (W/m**2/K**4)
ILW = incoming longwave radiation (W/m**2)
Ts = surface temperature (K);

SURFACE TEMPERATURE CALCULATIONS

The surface temperature was calculated using the calibration corrected temperature measurement, incoming longwave radiation (**ILW**) and surface emissivity values (Eq. 9). Values for incoming longwave radiation were calculated for each Barnes Model 12-1000 Modular Multiband Radiometer (MMR) data record.

ILW = (((air6) * 5.31E - 14) * 10.) - ((0.035) * (elev / 1000.) * (a * air**r)))**

where:

a = Stefan-Boltzmann constant (W/m**2/K**4)
air = MMR chopper or detector temperature (K) (see the Surface Reflectance Measured with a Mast-borne MMR Documentation)
ILW = incoming longwave (W/m**2)
elev = elevation of each site (m)

The equation is valid for clear daytime conditions (Deacon 1970). These values were averaged over the measurement period at a specific site. See the Incoming Longwave Radiation Data from UNL for these data.

Surface emissivity measurements were made under completely overcast sky conditions or at night and not in conjunction with the measurements made in this data set. An Everest infrared thermometer (IRT) Model 112C measured the temperature of the surface (**Tu**) and the temperature of the surface covered by an aluminum tent (**Ta**). The incoming longwave radiation under these conditions was determined using an IRT temperature measurement of an aluminum plate (t) of known emissivity (**ep**) and a thermocouple temperature of the plate (**Tp**).

The incoming longwave at the time of the surface emissivity measurement was calculated as:

ILW = (a * (t + 273.16)4 - ep * a * (Tp + 273.16)**4) / (1.0 - ep)**

where:

a = Stefan-Boltzmann constant (W/m**2/K**4)

Tu, or Ta, or T = a + b * Te

where:

Te = temperature measurement from the IRT (C); of the appropriate surface
a, b = calibration coefficients (see the *Other Calibration Information Section*)

Emissivity measurements were made over a sampling of the plots at a specific site during each IFC period in 1987. The emissivity is calculated as:

9Y. e = (a * (Tu + 273.16)4 - ILW) / (a * (Ta + 273.16)**4 - ILW)**

where:

a = Stefan-Boltzmann constant (W/m**2/K**4)

Emissivity values were averaged at each site by IFC for calculation of true surface temperatures. The following is a listing of the emissivity values used in 1987.

- Site 5 (2123-IRN): An average emissivity of 0.98 for IFC-2 was used for all dates in which data were taken (IFC-1 and IFC-2).
- Site 8 (3129-IRN): No emissivity values were measured, an assigned value of 0.98 was used.
- Site 18 (4439-IRN): An average emissivity of 0.97 from data taken during IFC-2 was used for IFC-1 and IFC-2 data; average emissivities of 0.98 and 0.97 were used for IFC-3 and IFC-4 data, respectively. Bare soil emissivity was 0.96.
- Site 26 (8739-IRN): An average emissivity of 0.96 from data taken during IFC-2 was used for IFC-1 and IFC-2 data; average emissivities 0.99 and 0.97 were used for IFC-3 and IFC-4 respectively.
- Site 28 (6943-IRN): An average emissivity of 0.98 from data taken during IFC-3 was used for IFC-1, IFC-2, and IFC-3; average emissivity of 0.98 was used for IFC-4 data.
- Site 29 (0847-IRN): An average emissivity of 0.98 was used for IFC-3 and IFC-4.
- Site 32 (4268-IRN): An average emissivity of 0.97 from data taken during IFC-2 was used for IFC-1 and IFC-2; average emissivity of 0.98 was used for IFC-3 and IFC-4 data.
- Site 40 (1246-IRN): An average emissivity of 0.98 from data taken during IFC-3 was used for IFC-1, IFC-2, and IFC-3; average emissivity of 0.96 was used for IFC-4 data.
- Site 42 (1445-PSP): An average emissivity of 0.99 from data taken during IFC-4 was used for IFC-2, IFC-3, IFC-4.
- Site 170 (0939-MMR): Emissivity data was take between IFC-2 and IFC-3 and averaged according to the mowing treatment. Average emissivities of 0.97, 0.98, 0.98, and 0.98 were used for the mowing plots of 5 cm height, 20 cm height or no mowing.

Emissivity measurements were made over a sampling of plots at site 811(4439-PAM) close to days of measurements for this data set in 1988. The measurements were averaged per site for the specific days listed. The following is a listing of the emissivity values used in 1988.

- May 24, 25, 27, June 28, and July 12 and 13 average emissivity of 0.991
- August 11 average emissivity of 0.983

Emissivity measurements were made over a sampling of plots at Sites 906 (2133-ECA), 916 (4439-ECV), and 966 (2437-BBS) close to days of the measurements for this data set in 1989. The values were averaged per site for specific days for the canopy and bare soil. The following are the emissivity values used in 1989:

- Station 916 (sitegrid 4439-REB), all days, average canopy emissivity of 0.964
- Station 916 (sitegrid 4439-REB), all days, average bare soil emissivity of 0.960
- Station 906 (sitegrid 2133-REB), all days, average canopy emissivity of 0.980
- Station 906 (sitegrid 2133-REB), all days, average bare soil emissivity of 0.980
- Station 966 (sitegrid 2437-REB), all days average bare soil emissivity of 0.960
- Station 966 (sitegrid 2437-REB), June 15 and July 14, average canopy emissivity of 0.9
- Station 966 (sitegrid 2437-REB), August 9, average canopy emissivity of 0.980

Data Processing Sequence:

Processing Steps:

The calibration coefficients used in equations 1, 3, 4, 6, 7, and 8 are listed in the *Other Calibration Information Section*.

Instruments on A-frame:

Equation 1 is used to convert the upright and inverted Eppley Precision Spectral Pyranometer voltages to incoming and reflected shortwave radiation (W/m**2), respectively. Equation 2 is used to calculate albedo.

Equation 3 is used to convert the Radiation Energy Balance Systems net radiometer voltages to net radiation (W/m**2).

Equation 4 is used to convert the upright and inverted LI-COR 190SA Quantum sensor voltages to incoming and reflected photosynthetically active radiation (uE/s/m**2). Equation 5 is used to calculate the ratio of reflected to incoming photosynthetically active radiation.

Equation 6 and 7 are used to convert the inverted Eppley Precision Infrared Radiometer voltages to reflected and emitted longwave radiation (W/m**2). Equation 6 is the preferred method since it eliminates any fluctuations from the battery in the thermistor-battery-resistance circuit. Both methods were used for comparison purposes.

SURFACE TEMPERATURE CALCULATIONS

The Everest Infrared Thermometers Model 112C and the Scheduler Plant Stress Monitor surface temperature measurements all used the following reduction method.

Equation 8 is used to correct the temperature measurement of the instrument using calibration-derived coefficients (Blad et al., 1990).

The calibration corrected temperature measurement of the instrument, incoming longwave radiation and surface emissivity values are used to calculate surface temperature using Equation 9 (Blad et al., 1976).

Processing Changes:

Not available at this revision.

Calculations:

Special Corrections/Adjustments:

None.

Calculated Variables:

- Shortwave Radiation,
- Net Radiation,
- Photosynthetically active radiation,
- Ratio of reflected to incoming photosynthetically active radiation,
- Calibration corrected temperature measurement,
- Surface Temperature,
- Incoming longwave radiation, and
- Emissivity.

Graphs and Plots:

None.

10. Errors:

Sources of Error:

Errors associated with the measurements can occur due to orientation of the platforms. The Scheduler plant stress monitor was hand-held causing a view zenith angle variation of +/- 10 degrees. The view azimuth angle for all platforms could only be measured to +/- 10 degrees.

The A-frame was kept at a constant height above the soil surface so that the target spot size may vary depending on canopy height.

With all of the platforms shadowing is another source of error. The A-frame had several instruments mounted on it with varying configuration in each year. An experiment was performed to estimate the error caused by shadowing for the reflected shortwave radiation measured by the Eppley Precision Spectral Pyranometer (PSP). Average relative errors from shadowing were found be: 1) -4.0% in 1987; 2) -5.7% in 1988; 3) -5.7% in 1989 for the inverted

PSP always mounted horizontally; and 4) -7.5% in 1989 for the inverted PSP inclined parallel with the slope of the individual plot at station 966 (sitegrid 2437). This experiment is described in Starks et al. (1991) for the configurations of 1987 and 1988. The configuration of 1989 was also tested in this experiment.

Variable cloud cover could be an error source if comparing measurements from the various plots within a measurement period.

Quality Assessment:

Data Validation by Source:

Not available at this revision.

Confidence Level/Accuracy Judgment:

On days with variable cloud conditions the data should be used with caution. The AMS incoming solar radiation data at the site or nearby site should be consulted.

On clear days the measurements fall within the precision of the instrument and errors that were discussed in previous sections.

Measurement Error for Parameters:

No quantitative assessment was made, see the *Confidence Level/Accuracy Judgment Section*.

Additional Quality Assessments:

FIS staff applied a general Quality Assessment (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. An attempt was made to find an explanation for unexpected high or low values, values outside of the normal physical range for a variable, or standard deviations that appeared inconsistent with the mean. In some cases, histog-rams were examined to determine whether outliers were consistent with the shape of the data distribution.

The discrepancies, which were identified, are reported as problems in 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); and
- 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:

As part of the FIS general QA of this data set the following discrepancies or errors in the data have been found at the specified location and date:

```
            Parameter                  Stn     Date           Problem
---------------------------  -----  ---------  --------------------
SHORTWAVE_RADTN_DOWN          26     1-JUL-87      35.14 LOW *
70    19-AUG-87     129.87 LOW
40     9-OCT-87     105.5 LOW
SHORTWAVE_RADTN_REFL_1
or SHORTWAVE_RADTN_REFL_2   70     9-AUG-87     789.25 HIGH +
ALBEDO                        18    30-MAY-87       0.861 HIGH
26     1-JUL-87       1.011 HIGH
70     19-AUG87       2 values > 0.991
40     9-OCT-87       1.001 HIGH
NET_RADTN_1 or NET_RADTN_1    18    30-MAY-87      65.81 LOW
IR_TEMP                       32    13-OCT-87       3.35 LOW
SURFACE_TEMP                  32    13-OCT-87       0.3 LOW
AIR_TEMP                      32    13-OCT-87         0 LOW
REL_HUMID                     32    13-OCT-87         0 LOW
29    16-AUG-87         2 LOW
42    20-AUG-87      4 values = 2 LOW
VAPOR_PRESS_DEFICIT           32    13-OCT-87         0 LOW
29    16-AUG-87       5.11 HIGH
42    20-AUG-87      4 values = or > 4.84
```

Footnotes:

- Low = means that the value given was lower than expected
- High = meant that the value given was higher than expected

1987:

Occasionally instruments malfunctioned. When this occurred, the erroneous temperature data were assigned values of 99.99. There are some errors in the observation times reported in the A-frame data and will effect the shortwave, net radiation, PAR and longwave parameters. They are:

- June 16 observation time of 1486 should be 1459. Observation time of 1786 should be 1800.
- July 6 observation time of 1772 should be 1759.
- July 14 observation time of 1686 should be 1700.
- July 15 observation time of 1872 should be 1859.
- Aug. 7 observation time of 2086 should be 2100.
- Aug. 11 observation time of 1787 should be 1801.
- Aug. 15 observation time of 1686 should be 1700.
- Aug. 19 observation time of 1992 should be 2006
- Aug. 20 observation time of 1772 should be 1759.
- Oct. 11 observation time of 1988 should be 2002.

The following A-frame data are erroneous:

- July 1 observation time of 1803
- Aug. 19 observation times of 2013 and 2016

1988:

Occasionally instruments malfunctioned. When this occurred, the erroneous temperature data were assigned values of 99.99. The erroneous data from the A-frame instruments (shortwave, net radiometer, PAR and longwave parameter) were assigned values of 0.0.

1989:

Occasionally instruments malfunctioned. When this occurred, the erroneous temperature data were assigned values of 99.99. The erroneous data from the A-frame instruments were assigned values of 9999.99.

Usage Guidance:

Before using these data, the incoming radiation from the AMS station at the site or nearby site should be checked for possible cloud-induced errors.

Any Other Relevant Information about the Study:

None.

12. Application of the Data Set:

This data set can be used to characterize bi-directional reflectance factor distributions in the solar principal plane for a tall grass prairie; estimate surface albedo from bi-directional reflectance factor and radiance data; determine the variability of reflected and emitted fluxes in selected spectral wavebands as a function of topography, vegetative community, and management practice; determine the influence of plant water status on surface reflectance factors; and determine Sun angle effects on radiation fluxes.

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 Surface Temperatures, Reflected and Emitted Radiation, and PAR from UNL data are available on FIFE CD-ROM Volume 1. The CD-ROM filename is as follows:

\DATA\SUR_REFL\UNL_SURF\GRIDxxxx\Yyyyy\ydddgrid.SRU

Where *xxxx* is the four digit code for the location within the FIFE site grid, *yyyy* are the four digits of the century and year (e.g., Y1987 = 1987). 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 (e.g., 061 = sixty-first day in the year). The filename extension (.*sfx*), identifies the data set content for the file (see the *Data Characteristics Section*) and is equal to .SRU for this data set.

17. References:

Satellite/Instrument/Data Processing Documentation.

Anonymous. 1986. LI-COR Terrestrial Radiation Sensors. Type SA Instruction Manual. LI-COR. Inc. Lincoln, NE (1986).

Anonymous. Instrumentation for the measurement of the components of solar and terrestrial radiation. The Eppley Laboratory, Inc. Newport, R.I.

Anonymous. 1987. Net Radiometer (Q*3) Instruction Manual. Radiation and Energy Balance Systems, Inc. (REBS). Seattle, WA (1987).

Anonymous. 1986. Model 112C infrared Thermometer operating manual. Everest Interscience, Inc. Fullerton, CA (1986).

Anonymous. 1987. Plant Stress Monitor Owner's Manual. Standard Oil Engineered Materials Company. Solon, OH 44139 (1987).

Journal Articles and Study Reports.

Albrecht, B. and S.K. Cox. 1977. Procedures for improving pyrgeometer performance. Journal of Applied Meteorology. 16:188-197

Blad, B.L. and J.J. Rosenberg. 1976. Measurement of crop temperature by leaf thermocouple, infrared thermometry and remotely sensed thermal imagery. Agronomy Journal. 68:635-641.

Blad, B.L., E.A. Walter Shea, C.J. Hays, and M.A. Mesarch. 1990.

Calibration of field reference panel and radiometers used in FIFE 1989. AgMet Progress Report 90-3. Department of Agricultural Meteorology. University of Nebraska-Lincoln. Lincoln, Nebraska. 68583-0728.

Conaway, J. and C.H.M. van Bavel. 1966. Remote measurement of surface temperature and its application to energy balance and evaporation studies of bare soil surfaces. U.S. Water Conservation Laboratory. Research Report.

Anonymous. No. 392. Interim report to USAE Com. Atmos. Sci. Lab. Fort Hauchuca, Ariz. 136 pp.

Deacon, E.L. 1970. The derivation of Swinbank's longwave radiation formula. Quarterly Journal of the Royal Meteorological Society. 96:313-319.

Fritschen, L. 1991. Personal Communication. University of Washington. Seattle, WA. 98195.

Fuchs, M. and C.B. Tanner. 1966. Infrared thermometry of vegetation. Agronomy Journal. 58:5976-601.

Iqbal, M. 1983. An introduction to solar Radiation. Academic Press: Toronto, Canada. 390 pp.

Sellers, P.J. and F.G. Hall. 1989. FIFE-89 Experiment Plan. GSFC/NASA. Greenbelt, MD 20771

Smith, E. 1988. personal communication. Department of Meteorology. Florida State University. Tallahassee, Florida.

Starks, P.J., J.M. Norman, B.L. Blad, E.A. Walter Shea, C.L. Walthall. 1991. Calculation of shortwave hemispherical reflectance (albedo) from bi-directional remotely sensed data. Remote Sensing of Environment. (accepted).

Tanner, B.D. 1990. Instrumentation of studying vegetation canopies for remote sensing in optical and thermal infrared regions - automated weather stations. Remote Sensing Reviews. 5 (1): 73-98.

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:

AMS Automated Meteorological Station CD-ROM Compact Disk-Read Only Memory DAAC Distributed Active Archive Center EOSDIS Earth Observing System Data and Information System FIFE First ISLSCP Field Experiment FIS FIFE Information System IFOV Instantaneous Field-of-View IRT Infrared Thermometer ISLSCP International Satellite Land Surface Climatology Project NIP Normal Incidence Pyrheliometer ORNL Oak Ridge National Laboratory PAR Photosynthetically Active Radiation PIR Eppley Precision Infrared Radiometer PSP Eppley Precision Pyranometer REBS Radiation Energy Balance Systems USDA_ARS United States Department of Agriculture/Agricultural Research Service URL Uniform Resource Locator UTM Universal Transverse Mercator VPD Vapor Pressure Deficit WAB Wind Aligned Blob

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

20. Document Information:

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Document Curator:
DAAC Staff

Document:
http://daac.ornl.gov/FIFE/guides/Soil_Reflectance_Data.html