SE-590 Ground Data: UNL (FIFE)

Summary:

The SE-590 Reflectance Factors and Radiances from UNL Data Set contains surface reflectance and viewing angle data that was collected at three sites within the FIFE study area via a SE590 mounted on a portable mast. All measurements were made on eleven days between July 15 and August 11, 1989. Measurements were typically coordinated with aircraft and/or satellite overpasses. 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. Solar radiation data at or near the specific site should be used to screen possible times of variable cloud cover.

Canopy, illumination, and viewing geometry are critical in determining the amount of reflected radiation received at the sensor. The measurements were predominantly made in the solar principal plane since the greatest variation in observed reflected radiation is expected to occur in that plane due to extremes in sunlit and shaded portions of the canopy (Norman and Walthall 1985). Reflected radiation measurements were converted to radiances and reflectance factor. Reflected radiation from a field reference panel corrected for non-perfect reflectance and sun angle was used as an estimate of the ideal Lambertian standard surface (Walter-Shea and Biehl 1990).

Table of Contents:

1. Data Set Overview:

Data Set Identification:

SE-590 Ground Data: UNL (FIFE).
(SE-590 Reflectance Factors and Radiances from UNL).

Data Set Introduction:

The SE-590 Reflectance Factors and Radiances from UNL Data Set contains surface reflectance and viewing angle data that was collected at three sites within the FIFE study area.

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 affects on radiation fluxes.

Summary of Parameters:

Surface reflectance and viewing angles.

Discussion:

The SE590 was mounted on a portable mast in order to achieve a spatial and temporal sampling at sites 906 (2133-BBS), 916 (4439-BBS), and 966 (2437-BBS). Measurements were periodically collected with the SE590 on the portable mast over a halon panel. Solar radiation data at or near the specific site should be used to screen possible times of variable cloud cover.

At sites 906 (2133-BBS) and 916 (4439-BBS), six (6) plots were identified. One of the 6 plots (plot number 999) 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. The portable mast was always aligned in the solar principal plane at the above sites. Measurements were typically coordinated with aircraft and/or satellite overpasses.

At site 966 (2437-BBS), sixteen (16) plots were identified. One of these plots was a bare soil plot that was treated in the aforementioned manner. At this site the portable mast was aligned parallel to the aspect of each plot (i.e., north-south or east-west). Plot number 991 was bare measured in north-south plane, 992 was bare soil measured in east-west plane.

All measurements were made on eleven days between July 15 and August 11, 1989.

Related Data Sets:

- 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 Measured from a Helicopter.
- SE-590 Leaf Level Spectral Observations from GSFC.
- Surface Temperature from UNL.
- Surface Temperature Measured at Multiple Angles.
- Surface Temperatures, Reflected and Emitted Radiation, and PAR from UNL.
- 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).

FIS Data Base Table Name:

SE590_GROUND_UNL_DATA.

2. Investigator(s):

Investigator(s) Name and Title:

Blaine L. Blad, Professor and Head
Elizabeth A. Walter-Shea, Asst. Professor
University of Nebraska

Title of Investigation:

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

Contact Information:

Contact 1:
Cynthia J. Hays
107 LWC
Lincoln, NE
68583-0728
(402)472-6701

Contact 2:
Mark A. Mesarch
Lincoln, NE
(402)472-5904
AGME012@129.93.200.1

Contact 3:
Elizabeth A. Walter-Shea
Lincoln, NE
(402)472-1553
AGME012@129.93.200.1

Requested Form of Acknowledgment.

The Leaf Area Index and PAR Determined from the UNL Light Bar Data were collected under the direction of B.L. Blad and E.A. Walter-Shea at the University of Nebraska. The dedicated efforts of C.J. Hays and M.A. Mesarch in the collection and preparation of these data is particularly appreciated.

3. Theory of Measurements:

Light radiation striking a vegetative canopy interacts with individual phytoelements (leaves, stems, branches) and the underlying substrate. The interaction depends on light quality, radiative form (direct or diffuse), illumination incidence angle, vegetative component optical properties and canopy architecture. Radiation is reflected, transmitted or absorbed. Researchers have shown that phytoelements and substrates are not perfect Lambertian reflectors, i.e., they do not reflect equally in all directions (Breece and Holmes 1971; Walter-Shea et al., 1989; Brakke et al., 1989; Irons et al., 1989). The amount of leaf area and leaf angle distribution will determine the amount of vegetation and substrate that is sunlit and shaded. The amount of vegetative and substrate and respective amounts of sunlit and shaded components in a scene will vary depending upon the angle at which it is viewed, i.e., the canopy is itself a non-Lambertian surface. Thus, canopy, illumination and viewing geometry are critical in determining the amount of reflected radiation received at the sensor. Our measurements were predominantly made in the solar principal plane since the greatest variation in observed reflected radiation is expected to occur in that plane due to extremes in sunlit and shaded portions of the canopy (Norman and Walthall 1985).

Reflected radiation measurements were converted to radiances and reflectance factor. The reflectance factor is the ratio of the target reflected radiant flux to an ideal radiant flux reflected by an ideal Lambertian standard surface irradiated in exactly the same way as the target. Reflected radiation from a field reference panel corrected for non-perfect reflectance and sun angle was used as an estimate of the ideal Lambertian standard surface (Walter-Shea and Biehl 1990).

4. Equipment:

Sensor/Instrument Description:

The Spectron Engineering SE590 is a portable battery operated spectroradiometer consisting of a CE500 data analyzer/logger controller, CE390 spectral detector head and an external battery charger/power supply. The CE500 is a self contained microprocessor-based controller which processes the signal from the head, amplifying and digitizing it with 12 bit resolution. For each spectral scan, the controller actuates the CE390 shutter, measures and stores the dark current, calculates optimum integration time, acquires the spectrum and automatically subtracts the noise for all 256 spectral elements. A series of scans can be taken and automatically averaged. The spectrum is stored in a double precision register which saves the entire 12-bit binary spectra until it is transmitted through the RS-232C port. The spectral detector head uses a defraction grating as the dispersive element; the spectrum is imaged onto a 256 element photodiode array. Each element integrates simultaneously acquiring the spectrum in a fraction of a second The interconnect cable from the spectral head to the controller couples the spectral signals to the controller, timing and control signals to the head. A shutter in the head, operated by the controller closes the light path for dark current measurements. For further information consult the SE590 operating manual. Serial Number 1571 was used.

Collection Environment:

Ground-based.

Source/Platform:

The SE590 was mounted 3.4 m above the soil surface on a portable, pointable mast which allowed the SE590 to view approximately the same surface area, regardless of the view zenith angle.

Source/Platform Mission Objectives:

Not applicable.

Key Variables:

Surface radiances and reflectance factors from 400 to 1000 nm at every 5 nm.

Principles of Operation:

The SE590 spectral detector head uses a defraction grating as the dispersive element; the spectrum is imaged onto a 256 element photodiode array. Each element integrates simultaneously acquiring the spectrum in a fraction of a second.

Sensor/Instrument Measurement Geometry:

The SE590 was mounted on a portable, pointable mast. The mast allowed the SE590 to view approximately the same surface area, regardless of the view zenith angle. The SE590 was located

at 3.4 m above the soil surface with a 15 degree field-of-view and a spot size of approximately 0.75 m diameter at nadir.

Manufacturer of Sensor/Instrument:

Spectron Engineering, Inc.
255 Yuma Court
Denver, Colorado 80223
(303) 733-1060

Calibration:

A post-season radiance calibration was supplemented by daily stability checks during the IFC-5 using a 30 cm integrating sphere operated at two lamp intensities. The 30 cm integrating sphere was located in an environmental chamber at the Kansas State Evapotranspiration Laboratory that was kept at a near constant ambient temperature during the checks.

Temperature sensitivity data were obtained when the chamber was not being used for stability checks. No corrections were made for the temperature sensitivity (Blad et al., 1990). A post-season wavelength calibration was performed. The post-season radiance and wavelength calibrations were performed at Goddard Space Flight Center.

Specifications:

Each SE590 has a unique wavelength associated with each of its 252 bands. So that wavelength to wavelength comparisons could be made among SE-590s used at FIFE a cubic spline interpolation was applied to the 252 bands to standardize the wavelengths to every 5 nm from 400 to 1000 nm.

Tolerance:

Results from the temperature dependency data indicated that measurements at wavelength of 1000 nm may result in discrepancies of approximately 50 [Watts][m^-2] [sr^-1][um^-1] if the instrument temperature varies for 16 to 43.5 degree C (Blad et al., 1990).

Frequency of Calibration:

Daily stability checks were only performed during the IFC-5 period. A post-season wavelength and radiance calibration were performed at Goddard Space Flight Center.

Other Calibration Information:

Calibration coefficients used for data reduction (Kim 1990).

Band	SE-590 Wavelength (nm)	Band	SE-590 Wavelength (nm)

1.0	374.46	51.0	504.70
2.0	377.00	52.0	507.65
3.0	379.52	53.0	510.61
4.0	382.01	54.0	513.57
5.0	384.47	55.0	516.53
6.0	386.92	56.0	519.49
7.0	389.34	57.0	522.46
8.0	391.75	58.0	525.42
9.0	394.15	59.0	528.39
10.0	396.53	60.0	531.35
11.0	398.91	61.0	534.31
12.0	401.28	62.0	537.27
13.0	403.64	63.0	540.22
14.0	406.00	64.0	543.16
15.0	408.36	65.0	546.10
16.0	410.72	66.0	549.03
17.0	413.09	67.0	551.96
18.0	415.47	68.0	554.87
19.0	417.85	69.0	557.78
20.0	420.25	70.0	560.69
21.0	422.66	71.0	563.59
22.0	425.08	72.0	566.48
23.0	427.53	73.0	569.37
24.0	429.99	74.0	572.25
25.0	432.48	75.0	575.13
26.0	435.00	76.0	578.00
27.0	437.54	77.0	580.87
28.0	440.12	78.0	583.74
29.0	442.71	79.0	586.60
30.0	445.34	80.0	589.46
31.0	447.98	81.0	592.32
32.0	450.66	82.0	595.17
33.0	453.35	83.0	598.03
34.0	456.07	84.0	600.88
35.0	458.80	85.0	603.73
36.0	461.56	86.0	606.58
37.0	464.34	87.0	609.43
38.0	467.13	88.0	612.28
39.0	469.94	89.0	615.13
40.0	472.77	90.0	617.98
41.0	475.61	91.0	620.83
42.0	478.47	92.0	623.69
43.0	481.34	93.0	626.54
44.0	484.23	94.0	629.40
45.0	487.12	95.0	632.26
46.0	490.03	96.0	635.12
47.0	492.95	97.0	637.99
48.0	495.87	98.0	640.86
49.0	498.81	99.0	643.73
50.0	501.75		

Band	**SE-590 Wavelength (nm)**	**Band**	**SE-590 Wavelength (nm)**
100.0	646.61	150.0	804.58
101.0	649.49	151.0	807.73
102.0	652.37	152.0	810.80
103.0	655.27	153.0	813.78

104.0	658.16	154.0	816.69
105.0	661.07	155.0	819.53
106.0	663.98	156.0	822.33
107.0	666.89	157.0	825.08
108.0	669.82	158.0	827.82
109.0	672.75	159.0	830.54
110.0	675.68	160.0	833.27
111.0	678.63	161.0	836.01
112.0	681.59	162.0	838.78
113.0	684.55	163.0	841.60
114.0	687.52	164.0	844.47
115.0	690.51	165.0	847.40
116.0	693.50	166.0	850.38
117.0	696.50	167.0	853.40
118.0	699.51	168.0	856.47
119.0	702.54	169.0	859.58
120.0	705.57	170.0	862.73
121.0	708.63	171.0	865.91
122.0	711.69	172.0	869.13
123.0	714.77	173.0	872.37
124.0	717.87	174.0	875.64
125.0	720.98	175.0	878.93
126.0	724.12	176.0	882.24
127.0	727.27	177.0	885.56
128.0	730.44	178.0	888.90
129.0	733.63	179.0	892.24
130.0	736.85	180.0	895.59
131.0	740.09	181.0	898.94
132.0	743.35	182.0	902.29
133.0	746.64	183.0	905.64
134.0	749.96	184.0	908.97
135.0	753.30	185.0	912.30
136.0	756.67	186.0	915.61
137.0	760.07	187.0	918.91
138.0	763.50	188.0	922.20
139.0	766.96	189.0	925.48
140.0	770.44	190.0	928.74
141.0	773.94	191.0	932.00
142.0	777.44	192.0	935.24
143.0	780.93	193.0	938.48
144.0	784.42	194.0	941.71
145.0	787.88	195.0	944.94
146.0	791.31	196.0	948.16
147.0	794.71	197.0	951.37
148.0	798.06	198.0	954.58
149.0	801.35	199.0	957.79

Band	**SE-590 Wavelength (nm)**	**Band**	**SE-590 Wavelength (nm)**
200.0	960.99	227.0	1049.86
201.0	964.20	228.0	1053.36
202.0	967.40	229.0	1056.87
203.0	970.61	230.0	1060.41
204.0	973.81	231.0	1063.98
205.0	977.02	232.0	1067.57
206.0	980.23	233.0	1071.18
207.0	983.44	234.0	1074.83

208.0	986.66	235.0	1078.50
209.0	989.89	236.0	1082.20
210.0	993.12	237.0	1085.93
211.0	996.36	238.0	1089.69
212.0	999.60	239.0	1093.48
213.0	1002.86	240.0	1097.30
214.0	1006.12	241.0	1101.16
215.0	1009.40	242.0	1105.05
216.0	1012.69	243.0	1108.98
217.0	1015.99	244.0	1112.94
218.0	1019.30	245.0	1116.93
219.0	1022.63	246.0	1120.97
220.0	1025.97	247.0	1125.04
221.0	1029.33	248.0	1129.15
222.0	1032.70	249.0	1133.31
223.0	1036.10	250.0	1137.50
224.0	1039.51	251.0	1141.73
225.0	1042.94	252.0	1146.01
226.0	1046.39		

Wavelength	**Gain**	**Wavelength**	**Gain**
nm	**mw/cm**2/sr/um**	**nm**	**mw/cm**2/sr/um**
400	263.633	700	350.783
405	274.057	705	351.602
410	282.613	710	354.681
415	296.082	715	358.079
420	303.871	720	360.935
425	312.753	725	364.852
430	324.930	730	371.416
435	332.479	735	368.823
440	339.977	740	365.294
445	345.739	745	360.659
450	354.622	750	355.083
455	365.716	755	349.410
460	374.271	760	345.561
465	375.009	765	340.358
470	378.029	770	334.961
475	384.020	775	331.620
480	390.908	780	328.776
485	395.546	785	326.009
490	398.697	790	321.703
495	401.076	795	318.355
500	404.482	800	315.319
505	409.679	805	309.614
510	413.277	810	302.738
515	417.860	815	294.983
520	419.434	820	285.112
525	422.846	825	275.076
530	424.758	830	267.174
535	424.648	835	259.284
540	427.125	840	253.517
545	431.156	845	247.698
550	427.081	850	243.706
555	419.876	855	241.022
560	416.169	860	239.341
565	418.159	865	238.080
570	420.895	870	234.559

575	425.116	875	229.539
580	430.024	880	223.907
585	433.456	885	217.964
590	435.884	890	211.060
595	434.030	895	203.281
600	428.958	900	195.992
605	423.899	905	188.603
610	421.058	910	181.105
615	423.795	915	173.707
620	428.056	920	166.607
625	428.043	925	158.849
630	424.601	930	151.206
635	420.466	935	146.534
640	413.988	940	140.942
645	409.616	945	134.797
650	406.709	950	128.332
655	401.884	955	122.288
660	393.546	960	115.972
665	387.686	965	110.053
670	379.607	970	103.848
675	369.267	975	97.878
680	359.933	980	91.951
685	354.666	985	85.684
690	352.157	990	80.127
695	350.419	995	74.694
1000	70.086		

5. Data Acquisition Methods:

The SE590 was mounted on a pointable, portable mast at a height of 3.4 m above the soil surface. The mast allowed the sensor to view the same surface area regardless of the viewing direction. A reference panel was positioned at a height of approximately 1 m above the soil surface. This panel was located within easy access to the plots and was measured to estimate the incoming radiation needed for data reduction. A measurement of the reference panel was made at the beginning of the measurement period. The mast was then positioned within a plot and aligned in the solar principal plane at sites 906 (2133-ECA) and 916 (4439-ECV) or parallel to the aspect of the plot (i.e., north-south or east-west) at site 966 (2437-BBS). Measurements were made at nadir and 20, 35 and 50 degree view zenith angles either side of nadir in the azimuthal plant of interest. At site 966 (2437-BBS) an additional view zenith angle perpendicular to the slope of the plot was included. An average of four SE590 scans were recorded. View zenith angles were measured by an inclinometer mounted on the mast. The mast was moved from plot to plot. After 20 to 25 minutes another measurement of the reference panel was made and the above procedure was repeated ending with a measurement of the reference panel.

6. Observations:

Data Notes:

Not available.

Field Notes:

- June 15 Site 966(2437-BBS), few cumulus clouds near sun for first measurement period then clear skies, measurement periods: 1358-1556, 1725-1934, and 2054-2108 GMT. Only a partial data set for the third measurement period.
- July 26 Site 916(4439-ECV), few clouds on horizon, measurement periods: 1400-1423 and 1425-1455 GMT.
- July 27 Site 916(4439-ECV), cumulus clouds, measurement period: 1451-1516 GMT.
- July 28 Site 916(4439-ECV) clear skies except for cumulus during last measurement period, measurement periods: 1400-1410, 1520-1536, 1630-1715, 1800-1835 GMT. Only a partial data set for the second measurement period.
- Aug. 4 Site 916(4439-ECV), clear skies, measurement periods: 1420-1500, 1700-1800, 1928-1929 GMT. Only a partial data set for the third measurement period.
- Aug. 6 Site 906(2133-ECA), clear skies, measurement periods: 1430-1500, 1600-1630, 1800-1840, 1930-2000, 2045-2105 GMT.
- Aug. 7 Site 906(2133-ECA), cumulus during first measurement period, then clear skies, measurement periods: 1730-1800 and 1945-2010 GMT.
- Aug. 8 Site 916(4439-ECV), clear skies, measurement periods: 1415-1510, 1620-1735, 2010-2030, 2110-2135 GMT.
- Aug. 9 Site 966(2437-BBS), clear skies for first measurement period, then cumulus, measurement periods: 1530-1630 and 1730-1840 GMT. No Reflectance Factors for first part of the second measurement period.
- Aug. 10 Site 906(2133-ECA), possible cirrus, measurement period: 1535-1600 GMT.
- Aug. 11 Site 916(4439-ECV), lots of cumulus clouds, measurement period: 2150-2230 GMT. No reflectance factors for the measurement period.

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:

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

Plots at sites 906 (2133-BBS) and 916 (4439-BBS) were located northeast of the Wind Aligned Blob (WAB) site (Sellers et al., 1989). A topography file containing the northing and easting of the plots at each site except for site 966 (2437-BBS), is available in the GRABBAG section of FIFE CD-ROM Volume 1 in the UNL directory, in file UNL_PLOT.T89. This file also includes slope, aspect, soil depth and vegetative height of the plots, for all sites.

Measurements were made at the following three locations within the FIFE study area:

SITEGRID	STN	NORTHING	EASTING	LATITUDE	LONGITUDE	ELEV	SLOPE	ASPECT
2133-BBS	906	4329726	711604	39 05 34	-96 33 12	443	1	TOP
2437-BBS	966	4329150	712375	39 05 15	-96 32 41			
4439-BBS	916	4325193	712773	39 03 06	-96 32 28	443	2	N

Spatial Coverage Map:

Not available.

Spatial Resolution:

The footprint (surface area viewed by the SE590 at a height of 3.4 meters from the soil surface) had a diameter of 0.75 m at nadir and changed with view zenith angle. The plot size was approximately 3 m x 3 m.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

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

Temporal Coverage Map:

Not available.

Temporal Resolution:

The measurement time ranged from 1358 to 2219 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. Data were obtained at only one site per day. A maximum of five (5) discrete measurement periods throughout the day was obtained. Measurements were made between June 15, 1989 and August 11, 1989. During this period measurements were made on the following 11 days:

OBS_DATE:

- 15-JUN-89
- 26-JUL-89
- 27-JUL-89
- 28-JUL-89
- 04-AUG-89
- 06-AUG-89
- 07-AUG-89
- 08-AUG-89
- 09-AUG-89
- 10-AUG-89
- 11-AUG-89

Data Characteristics:

The SQL definition for this table is found in the SE_UNL.TDF file 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 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 start time of the observation [GMT]

in GMT. The format is (HHMM).	
VIEW_AZIM_ANG The view azimuth angle. With North=0, East=90	[degrees from North]
VIEW_ZEN_ANG The view zenith angle of the observations. With a nadir view, view zenith angle=0	[degrees]
SOLAR_AZIM_ANG The solar azimuth angle. With North=0, East=90	[degrees from North]
SOLAR_ZEN_ANG The solar zenith angle.	[degrees]
PLOT The identification number assigned to a specific plot within a site. Plots numbered 999 are bare soil.	
SLOPE For the slope site this column contains measurements of the slope of the measured plot in degrees.	
ASPECT For the slope site this column contains measurements of the aspect of the measured plot in degrees, with north=0 and east=90. With aspect defined as the direction a line perpendicular from the surface points.	
WAVLEN The wavelength at which the observation was made.	[microns]
REFL The average percent reflectance. Radiance values have been resampled using a cubic spline interpolation then ratioed with calibration panel data.	[percent]

```
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).
```

Footnote:

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.

Sample Data Record:

SITEGRID_ID	STATION_ID	OBS_DATE	OBS_TIME	PLOT	SLOPE
4439-BBS	916	04-AUG-89	1730	1	
4439-BBS	916	04-AUG-89	1730	1	
4439-BBS	916	04-AUG-89	1730	1	
4439-BBS	916	04-AUG-89	1730	1	

ASPECT	VIEW_AZIM_ANG	VIEW_ZEN_ANG	SOLAR_AZIM_ANG	SOLAR_ZEN_ANG
325	0	146.9	25.2	
325	0	146.9	25.2	
325	0	146.9	25.2	
325	0	146.9	25.2	

WAVLEN	REFL	FIFE_DATA_CRTFCN_CODE	LAST_REVISION_DATE
.4	2.23	CPI	11-JAN-91
.405	2.21	CPI	11-JAN-91
.41	2.25	CPI	11-JAN-91
.415	2.34	CPI	11-JAN-91

8. Data Organization:

Data Granularity:

Measurements were not continuously made but were in discrete measurement periods depending on the number of plots in a site and coordination with aircraft and satellite overpasses. Data were obtained at only one site per day. A maximum of five (5) discrete measurement periods throughout the day was obtained.

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:

Ls(t,j) or Lp(t1,j) or Lp(t2,j) = Vc(t,j) / [G(j)] [1]

where:

G(j) = wavelength gain (mW/cm**2/sr/um)
Ls(t,j) or Lp(t1,j) or **Lp(t2,j)** = wavelength spectral radiance for surface or reference panel (W/m**2/sr/um)
j = wavelength (400-1000 nm in 5 nm increments
t, t1, t2 = time of measurement

Lp(t,j) = Lp(t1,j) + {[(t - t1) / (t2 - t1)] * [Lp(t2,j) - Lp(t1,j)]} [2]

where:

Lp(t1,j) and **Lp(t2,j)** = wavelength reference panel radiance bracketing the surface radiances at times t1 and t2 (W/m**2/sr/um)

Lp(t,j) = wavelength radiance of the reference panel at the surface radiance time t (W/m**2/sr/um)

Lp(t,j) = Lp(t1,j) * [sin(sea(t1)) / sin(sea(t))] [3]

where:

sea(t1) = solar elevation angle at time t1
sea(t) = solar elevation angle at time t

RF(t,j) = Ls(t,j) / (Lp(t,j) / RFp(t,j)) [4]

where:

Ls(t,j) = wavelength surface radiance at time t(W/m**2/sr/um)
RF(t,j) = wavelength surface reflectance factor at time t (%)
RFp(t,j) = wavelength reflectance factor for the reference panel at time t (%)

Derivation Techniques and Algorithms:

A Lapsphere molded halon reference panel was used. This panel was calibrated in September 1989 by the University of Nebraska following the procedure of Jackson et al. (1987).

The calibration yields the coefficients to a third order polynomial of the form:

RFp(t,j) = C0(j) + C1(j) * ZEN + C2(j) * ZEN2 + C3(j) * ZEN**3**

where:

C0, C1, C2, and **C3** = the calibration coefficients for wavelength **j**
ZEN = solar zenith angle at time **t** of the surface measurement (degrees)

The result of this equation RFp(t,j) is used in equation [4].

Panel coefficients

Wave-Length	C0	C1	C2	C3
400	0.1020691E+01	0.2307796E-02	-0.7176625E-04	0.2028643E-06
405	0.1023635E+01	0.2348937E-02	-0.7409656E-04	0.2168063E-06
410	0.1027976E+01	0.1691810E-02	-0.5849818E-04	0.1115234E-06
415	0.1026675E+01	0.1986200E-02	-0.6609871E-04	0.1656263E-06
420	0.1028462E+01	0.1928542E-02	-0.6473542E-04	0.1522611E-06
425	0.1030961E+01	0.1599423E-02	-0.5722518E-04	0.1032186E-06
430	0.1032524E+01	0.1483927E-02	-0.5489080E-04	0.9058423E-07
435	0.1031159E+01	0.1572472E-02	-0.5582624E-04	0.8927227E-07
440	0.1033558E+01	0.1498712E-02	-0.5456564E-04	0.8286727E-07
445	0.1033324E+01	0.1569419E-02	-0.5690657E-04	0.1039715E-06

450	0.1036139E+01	0.1305071E-02	-0.5105510E-04	0.6360571E-07
455	0.1038211E+01	0.1159643E-02	-0.4794833E-04	0.4357352E-07
460	0.1036826E+01	0.1354819E-02	-0.5326012E-04	0.8434483E-07
465	0.1038920E+01	0.1132739E-02	-0.4769623E-04	0.4260698E-07
470	0.1039643E+01	0.1113157E-02	-0.4713262E-04	0.3869216E-07
475	0.1039233E+01	0.1153365E-02	-0.4839558E-04	0.4917332E-07
480	0.1040030E+01	0.1155133E-02	-0.4909308E-04	0.5609697E-07
485	0.1041885E+01	0.1005832E-02	-0.4571612E-04	0.3395124E-07
490	0.1039826E+01	0.1166439E-02	-0.4888924E-04	0.5190591E-07
495	0.1040985E+01	0.1065573E-02	-0.4634565E-04	0.3235320E-07
500	0.1042588E+01	0.9224978E-03	-0.4325799E-04	0.1215631E-07
505	0.1044681E+01	0.7519039E-03	-0.3927152E-04	-0.1493404E-07
510	0.1043211E+01	0.8573297E-03	-0.4200791E-04	0.4340810E-08
515	0.1042012E+01	0.9367443E-03	-0.4354084E-04	0.1444452E-07
520	0.1041645E+01	0.9941544E-03	-0.4520349E-04	0.2767669E-07
525	0.1042760E+01	0.8751338E-03	-0.4183103E-04	-0.2532645E-09
530	0.1044702E+01	0.6598454E-03	-0.3724032E-04	-0.2877237E-07
535	0.1042191E+01	0.9069606E-03	-0.4292930E-04	0.8617134E-08
540	0.1043134E+01	0.8160212E-03	-0.4042930E-04	-0.1107292E-07
545	0.1041051E+01	0.9394131E-03	-0.4364209E-04	0.1395316E-07
550	0.1043180E+01	0.7566459E-03	-0.3943769E-04	-0.1579043E-07
555	0.1044188E+01	0.7296551E-03	-0.3916740E-04	-0.1698103E-07
560	0.1043210E+01	0.7575643E-03	-0.3901382E-04	-0.2262007E-07
565	0.1042763E+01	0.8187740E-03	-0.4061343E-04	-0.8930165E-08
570	0.1044980E+01	0.6854801E-03	-0.3789858E-04	-0.2640262E-07
575	0.1043569E+01	0.7628911E-03	-0.3926709E-04	-0.1867208E-07
580	0.1042724E+01	0.8381633E-03	-0.4131085E-04	-0.4006738E-08
585	0.1042959E+01	0.7833779E-03	-0.4003083E-04	-0.1313729E-07
590	0.1042308E+01	0.8542608E-03	-0.4146493E-04	-0.4291500E-08
595	0.1043040E+01	0.7772386E-03	-0.3944546E-04	-0.2026909E-07
600	0.1044935E+01	0.6830641E-03	-0.3784099E-04	-0.2870515E-07
605	0.1045260E+01	0.6352458E-03	-0.3627764E-04	-0.4183683E-07
610	0.1044507E+01	0.7371207E-03	-0.3916481E-04	-0.1862948E-07
615	0.1044152E+01	0.7730190E-03	-0.3948137E-04	-0.1895644E-07
620	0.1043966E+01	0.7937066E-03	-0.4021111E-04	-0.1255158E-07
625	0.1044246E+01	0.7586920E-03	-0.3928547E-04	-0.1985262E-07
630	0.1045597E+01	0.6534198E-03	-0.3650992E-04	-0.4194394E-07
635	0.1044604E+01	0.8030013E-03	-0.4020498E-04	-0.1586309E-07
640	0.1044003E+01	0.8092978E-03	-0.4004213E-04	-0.1822999E-07
645	0.1044257E+01	0.7523490E-03	-0.3898273E-04	-0.2239451E-07
650	0.1045403E+01	0.6644642E-03	-0.3657396E-04	-0.4320698E-07
655	0.1046331E+01	0.6109984E-03	-0.3529197E-04	-0.5168750E-07
660	0.1044507E+01	0.8011676E-03	-0.3970652E-04	-0.2104697E-07
665	0.1046092E+01	0.5774825E-03	-0.3407302E-04	-0.6149129E-07
670	0.1046652E+01	0.6211065E-03	-0.3607046E-04	-0.4385477E-07
675	0.1043847E+01	0.7546030E-03	-0.3838479E-04	-0.3292595E-07
680	0.1044203E+01	0.7235191E-03	-0.3768374E-04	-0.3605060E-07
685	0.1042028E+01	0.8885071E-03	-0.4118552E-04	-0.1339236E-07
690	0.1041722E+01	0.8982174E-03	-0.4130272E-04	-0.1182499E-07
695	0.1043119E+01	0.7811239E-03	-0.3854480E-04	-0.3111853E-07
700	0.1044344E+01	0.6963478E-03	-0.3671847E-04	-0.4454136E-07
705	0.1044987E+01	0.6712667E-03	-0.3628980E-04	-0.4698841E-07
710	0.1041283E+01	0.9727916E-03	-0.4312553E-04	-0.2159273E-08
715	0.1040946E+01	0.9864625E-03	-0.4347726E-04	0.1658801E-08
720	0.1040259E+01	0.1072143E-02	-0.4537162E-04	0.1533203E-07
725	0.1040856E+01	0.1005566E-02	-0.4269822E-04	-0.1164932E-07
730	0.1041606E+01	0.8903170E-03	-0.4111425E-04	-0.1515658E-07

735	0.1043015E+01	0.8589865E-03	-0.4066363E-04	-0.2088457E-07
740	0.1046650E+01	0.5306230E-03	-0.3325386E-04	-0.7159644E-07
745	0.1044990E+01	0.7686343E-03	-0.3913624E-04	-0.3107813E-07
750	0.1046234E+01	0.6327561E-03	-0.3658425E-04	-0.4737320E-07
755	0.1047823E+01	0.6211554E-03	-0.3718316E-04	-0.4056453E-07
760	0.1042600E+01	0.9254874E-03	-0.4231824E-04	-0.1316337E-07
765	0.1044418E+01	0.8084020E-03	-0.3931320E-04	-0.3034765E-07
770	0.1043483E+01	0.7766855E-03	-0.3781739E-04	-0.4062813E-07
775	0.1044584E+01	0.7153847E-03	-0.3646227E-04	-0.5397206E-07
780	0.1043379E+01	0.7074788E-03	-0.3665062E-04	-0.5043588E-07
785	0.1043978E+01	0.7381677E-03	-0.3829550E-04	-0.3632283E-07
790	0.1043675E+01	0.7494834E-03	-0.3794876E-04	-0.4191600E-07
795	0.1039806E+01	0.1037861E-02	-0.4525806E-04	0.1293397E-07
800	0.1043500E+01	0.9185881E-03	-0.4322741E-04	-0.1163219E-08
805	0.1042646E+01	0.8156832E-03	-0.3998216E-04	-0.2506371E-07
810	0.1046820E+01	0.4941361E-03	-0.3317775E-04	-0.6669556E-07
815	0.1040511E+01	0.1039870E-02	-0.4522509E-04	0.1189255E-07
820	0.1038469E+01	0.1295986E-02	-0.5196943E-04	0.6058429E-07
825	0.1042260E+01	0.9458050E-03	-0.4312630E-04	-0.3836924E-08
830	0.1045250E+01	0.7185282E-03	-0.3877058E-04	-0.2936804E-07
835	0.1045535E+01	0.6508042E-03	-0.3633434E-04	-0.4933092E-07
840	0.1037599E+01	0.1296161E-02	-0.5030810E-04	0.3964285E-07
845	0.1046608E+01	0.6270441E-03	-0.3644990E-04	-0.4800667E-07
850	0.1045323E+01	0.7754005E-03	-0.3969374E-04	-0.2803267E-07
855	0.1042171E+01	0.7959635E-03	-0.3869225E-04	-0.3927269E-07
860	0.1043839E+01	0.8561251E-03	-0.4141981E-04	-0.1528441E-07
865	0.1042140E+01	0.9965700E-03	-0.4448181E-04	0.4938349E-08
870	0.1050822E+01	0.1312364E-03	-0.2362573E-04	-0.1425405E-06
875	0.1043396E+01	0.7739614E-03	-0.3876894E-04	-0.3688082E-07
880	0.1045459E+01	0.8417810E-03	-0.4006278E-04	-0.3309392E-07
885	0.1045308E+01	0.8914825E-03	-0.4168651E-04	-0.2233586E-07
890	0.1041503E+01	0.1087362E-02	-0.4440085E-04	-0.1277023E-07
895	0.1044998E+01	0.9936822E-03	-0.4378704E-04	-0.8000492E-08
900	0.1044516E+01	0.9439814E-03	-0.4285062E-04	-0.1423759E-07
905	0.1051446E+01	0.2078550E-03	-0.2469360E-04	-0.1449934E-06
910	0.1039938E+01	0.1304500E-02	-0.5042315E-04	0.3517433E-07
915	0.1037042E+01	0.1588295E-02	-0.5866167E-04	0.1018471E-06
920	0.1049954E+01	0.5902972E-03	-0.3580553E-04	-0.5499579E-07
925	0.1049048E+01	0.7595964E-03	-0.4067645E-04	-0.2342711E-07
930	0.1050720E+01	0.7863740E-03	-0.4294367E-04	0.2288731E-08
935	0.1046086E+01	0.9521864E-03	-0.4349145E-04	-0.1004916E-07
940	0.1024226E+01	0.3142879E-02	-0.9418973E-04	0.3319447E-06
945	0.1034131E+01	0.1843622E-02	-0.6248886E-04	0.1157058E-06
950	0.1030182E+01	0.2473955E-02	-0.7645961E-04	0.1948248E-06
955	0.1031775E+01	0.2705489E-02	-0.8893934E-04	0.3228065E-06
960	0.1027560E+01	0.2148790E-02	-0.6621033E-04	0.1178804E-06
965	0.1034866E+01	0.2427981E-02	-0.7996300E-04	0.2375677E-06
970	0.1038287E+01	0.1697609E-02	-0.6165585E-04	0.1109473E-06
975	0.1035191E+01	0.1719718E-02	-0.5832063E-04	0.7156511E-07
980	0.1032137E+01	0.2116019E-02	-0.7136896E-04	0.1721857E-06
985	0.1019492E+01	0.3677361E-02	-0.1085873E-03	0.4309212E-06
990	0.1035775E+01	0.1490417E-02	-0.5273831E-04	0.1846581E-07
995	0.1031226E+01	0.2336911E-02	-0.7589278E-04	0.1936309E-06
1000	0.1022056E+01	0.3207516E-02	-0.9718610E-04	0.3552770E-06

Data Processing Sequence:

Processing Steps:

Each SE590 has a unique wavelength associated with each of its 252 bands. So that wavelength to wavelength comparisons could be made among SE-590s used at FIFE a cubic spline interpolation was applied to the 252 bands to standardize the wavelengths to every 5 nm from 400 to 1000 nm.

Equation 1 was then used to change the corrected voltages to radiances. The gains and offsets for each MMR are listed in 5.2.3 (Kim 1990). Usage of Equations 2 and 3 is dependent on the measurement time interval of the reference panel. These equations interpolate the reference panel radiance output for the time of surface reflectance measurements. If measurements of the reference panel are made less then every 30 minutes equation 2 is then applied (Bauer et al., 1981). If the measurements of the reference panel are greater then 30 minutes apart then equation 3 is used. The reference panel reflectance factor for each surface measurement time is determined as explained in the *Derivation Techniques and Algorithms Section*. This provides a correction for the reference panel's non-Lambertian properties and the dependence on solar zenith angle. Equation 4 is then used to calculate the surface reflectance factor using surface and reference panel radiances and the reference panel reflectance factor.

Processing Changes:

None known at this revision.

Calculations:

Special Corrections/Adjustments:

None reported at this revision.

Calculated Variables:

- Wavelength spectral radiance for surface,
- Wavelength radiance of the reference panel at the surface radiance time t,
- Wavelength surface reflectance factor at time t (%), and
- Surface reflectance factor.

Graphs and Plots:

None.

10. Errors:

Sources of Error:

Errors associated with the measurements can occur due to orientation of the SE590. The view zenith angle could only be measured to +/- 2 degrees and the view azimuth angle could only be measured to + or - 10 degrees.

The shadowing caused by the SE590 and other instruments on the portable mast is another source of error when measuring the "hot spot" area.

Variable cloud cover could be an error source with reflectance factors since the incoming radiation measurements were not made simultaneously with the surface measurements but are interpolated assuming clear sky conditions.

Quality Assessment:

Data Validation by Source:

Comparison's have been made with PARABOLA, helicopter mounted radiometers and MMR measurements.

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:

Not available at this revision.

Additional Quality Assessments:

Not available at this revision.

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:

- Missing reflectance factors are denoted with a 99.99.
- Missing radiances are denoted with a 999.99.
- On June 15, 1989 at sitegrid 2437-BBS all data are suspect. Use with caution.

Usage Guidance:

Before using reflectance factors the incoming radiation from the AMS station at the site or nearby site should be checked for possible cloud-induced error in reflectance factors.

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 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 affects 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 SE-590 Reflectance Factors and Radiances from UNL are available on FIFE CD-ROM Volume 1. The CD-ROM filename is as follows:

\DATA\SUR_REFL\SE5_UNL\GRIDxxxx\yyddd\ydddgrid.Unn

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., 87 = 1987), 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.Unn*, 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), *ddd* is the day of the year, and *nn* is the number of spectra during a day, when all the spectra are

ordered chronologically and all spectra for a minute are in the same file. The content of each file is described in the *Data Characteristics Section*.

17. References:

Satellite/Instrument/Data Processing Documentation.

Spectron Engineering, Inc. Operating Manual: SE590 field-portable data-logging spectroradiometer. Spectron Engineering. Denver, CO 80223.

Journal Articles and Study Reports.

Bauer, M.E., B.F. Robinson, C. Daughtry, and L.L. Biehl. 1981. Field Measurement Workshop. Oct. 14-16, Laboratory for application of Remote Sensing. Purdue University. Lafayette, Indiana.

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.

Brakke, T.W., J.A. Smith, and J. M. 1989. Bi-directional scattering of light from tree leaves. Remote Sensing of Environment. 29:175-183.

Breece, H.T. III and R.A. Holmes. 1971. Bi-directional scattering characteristics of healthy green soybean and corn leaves in vivo. Applied Optics. 10:119-127.

Irons, J.R., R.A. Weismiller, and G.W. Peterson. 1989. Soil reflectance In G. Asrar (ed.). Theory and Applications of Optical Remote Sensing. John Wiley & Sons. New York. p.66-106.

Jackson, R.D., S.M. Moran, P.N. Slater, and S.F. Biggar. 1987. Field calibration of reference reflectance panels. Remote Sensing of Environment. 17:103-108.

Kim, M. 1990. personal communication. GSFC/NASA. Greenbelt, MD 20771.

Norman, J.M. and C.L.Walthall. 1985. Analysis of an empirical model for hemispherical albedo computation. Final Report for Contract. #S-19583-D.

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

Walter-Shea, E.A., J.M. Norman, and B.L. Blad. 1989. Bi-directional reflectance and transmittance in corn and soybean. Remote Sensing of Environment. 29:161-174.

Walter-Shea, E.A. and L.L. Biehl. 1990. Measuring vegetation spectral properties. Remote Sensing Review. 5:179-205.

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:

APAR Absorbed Photosynthetically Active Radiation DAAC Distributed Active Archive Center EOSDIS Earth Observing System Data and Information System FIFE First ISLSCP Field Experiment FIS FIFE Information System IPAR Intercepted Photosynthetically Active Radiation ISLSCP International Satellite Land Surface Climatology Project LAI Leaf Area Index MMR Modular Multiband Radiometer ORNL Oak Ridge National Laboratory UNL University of Nebraska-Lincoln URL Uniform Resource Locator WAB Wind Aligned Blob

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

20. Document Information:

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Warning: This document has not been checked for technical or editorial accuracy by the FIFE Information Scientist. There may be inconsistencies with other documents, technical or editorial errors that were inadvertently introduced when the document was compiled or references to preliminary data that were not included on the final CD-ROM.

Previous versions of this document have been reviewed by the Principal Investigator, the person who transmitted the data to FIS, a FIS staff member, or a FIFE scientist generally familiar with the data.

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Document Curator:

DAAC Staff

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