Parabola Data (FIFE)

Summary:

The Surface Reflectances Measured by the PARABOLA Data Set contains measurements from the Portable Apparatus or Rapid Acquisitions of Bi-directional Observations of Land and Atmosphere (PARABOLA) instrument. The focus of this research was to characterize the variation in vegetation reflectance as a function of solar and sensor viewing geometry, wavelength, and plant canopy biophysical characteristics. An understanding of these relationships is necessary for meaningful biophysical and ecological interpretations of measurements acquired from airborne and satellite sensors. The PARABOLA is able to measure these variations in reflectance because it measures at different viewing angles and at 3 spectral bands. The data are averaged reflectance factors of the Konza Prairie at different view angles and at 3 wavelength bands throughout the day. PARABOLA measurements were made during each of the 5 FIFE Intensive Field Campaigns from five locations within the FIFE study area.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Parabola Data (FIFE).
(Surface Reflectances Measured by the PARABOLA).

Data Set Introduction:

The Surface Reflectances Measured by the PARABOLA Data Set contains measurements from the PARABOLA instrument. The data set contains averaged reflectance factors of the Konza Prairie at different view angles and at 3 wavelength bands throughout the day.

Objective/Purpose:

This study had the following objectives:

- Provide bi-directional reflectance measurements of the various prairie cover types.
- 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.
- Determine sun angle affects on radiation fluxes.
- Estimate surface albedo from bi-directional reflectance factor and radiance data.
- Compute and validate satellite albedo estimates using surface-measured directional and spectral reflectance characteristics.
- Develop seasonal satellite albedo computational algorithms for FIFE study area.

Summary of Parameters:

Radiance, reflectance, and viewing angle.

Discussion:

This data set contains measurements from the Portable Apparatus for Rapid Acquisitions of Bi-directional Observations of Land and Atmosphere (PARABOLA) instrument. The PARABOLA, is an instrument specifically designed to measure variations in vegetation reflectance as a function of solar and sensor viewing geometry, wavelength, and plant canopy biophysical characteristics. The data are averaged reflectance factors of the Konza Prairie at different view angles and at 3 wavelength bands throughout the day. The raw data for each channel and time period were binned by creating 144 conical bins within the spherical space which surrounds the instrument, and then the data points which fall within each bin are averaged. PARABOLA measurements were made during each of the 5 FIFE Intensive Field Campaigns from five locations within the FIFE study area.

Related Data Sets:

- SE-590 Spectroradiometer Reflectance Factors from GSFC. This data set contains nadir and off nadir SE-590 (ground measured) spectrometer radiances and reflectances measurements from the Goddard Space Flight Center SRB group. These data were collected in conjunction with the PARABOLA data.

- SE-590 Reflectance Factors and Radiances from UNL. This data set contains nadir and off nadir SE-590 spectrometer radiances and reflectances measurements from the University of Nebraska group.
- SE-590 Reflectance Factors and Radiances Measured from a Helicopter. This data set contains reflectance measured with the helicopter mounted SE-590 spectrometer.
- Biophysical Properties of Vegetation. This data set contains measurements of leaf area index and biomass of difference canopy components.
- Vegetation Species and Cover Abundance. This data set contains the species composition data, by site and data.
- Vegetation Species Reference. Konza LTER species names, codes, types and other reference information.
- Leaf Area Index and PAR Determined from UNL Light Bar Measurements. This data set contains data from the light bar (LICOR LI-191SA) collected by University of Nebraska group. The variables collected were photosynthetically active radiation, Absorbed photosynthetically active radiation, Intercepted photosynthetically active radiation and Leaf Area Index.
- Leaf Area Index and PAR Determined from KSU Light Bar Measurements. This data set contains data from the light bar collected by the Kansas State University Staff Science. Leaf Area Index and photosynthetically active radiation above and below the canopy were measured.
- Indirect Leaf Area Index Obtained from the KSU Light Wands. This data set contains data from the LICOR LAI-2000 Plant Canopy Analyzer collected by KSU staff science.
- Indirect Leaf Area Index Obtained from the UNL Light Wands. This data set contains data from the LICOR LAI-2000 Plant Canopy Analyzer collected by the UNL group.

FIS Data Base Table Name:

PARABOLA_DATA.

2. Investigator(s):

Investigator(s) Name and Title:

Staff Science.

Title of Investigation:

Albedo and Thermal Properties from Multiple Directional Surface Properties.

Contact Information:

Contact 1:
Dr. Donald W. Deering
NASA/GSFC
Greenbelt, MD

(301) 286-9186
ddeering@gsfcmail.nasa.gov

Contact 2:
Dr. Elizabeth Middleton
NASA/Goddard Sp. Fl. Ctr.
Greenbelt, MD
(301) 286-8344
middleton@pldsg3.gsfc.nasa.gov

Requested Form of Acknowledgment.

The Surface Reflectances Measured by the PARABOLA were collected and analyzed by Dr. Donald W. Deering as part of the Surface Radiance and Biology (SRB3) study.

3. Theory of Measurements:

The focus of this research was to characterize the variation in vegetation reflectance as a function of solar and sensor viewing geometry, wavelength, and plant canopy biophysical characteristics. An understanding of these relationships is necessary for meaningful biophysical and ecological interpretations of measurements acquired from airborne and satellite sensors. The PARABOLA is able to measure these variations in reflectance because it measures at different viewing angles and at 3 spectral bands.

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 (Walter-Shea 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 geometries are critical in determining the amount of reflected radiation received at the sensor.

Reflected radiation measurements were converted to radiances and reflectance factor (the ratio of reflected radiance to incident radiance). 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 basic PARABOLA instrument is a three channel, rotating head radiometer consisting of three primary units - the sensor head, data recording unit, and internal power pack. The sensor head is composed of a motor-driven tow-axis gimbel on which three detector units are jointly mounted. The three detectors include two silicon and one germanium solid state detectors, with filters configured to correspond to Thematic Mapper spectral bands 3, 4, and 5 (630-690, 760-900, and 1550-1750 nm), respectively. They are temperature regulated (by cooling or beating) through thermoelectric proportional control circuits. Also, due to the tremendous range in target brightness that can be expected in scanning a 2 hemisphere field-of-view, and auto-ranging amplifier is used to switch the gain levels back-and-fourth by factors of 1, 10, and 100 to maintain maximum radiometric sensitivity. The detector cones confine the fields-of-view to 15 degree. The two-axis, two motor rotation of the head enables a near-complete sampling of the entire sky/ground sphere. There is a 15 degree exclusion area toward the mounting device due to mechanical limitations.

Collection Environment:

Ground-based.

Source/Platform:

The primary mounting device is a lightweight, collapsible boom apparatus, called the Transportable Pickup Mount System or TPMS, whose primary unit consists of an aluminum triangular truss that decouples as four 2m long sections. At the top end resides a detachable, two-axis motorized PARABOLA radiometer mounting and leveling head with a camera mounting attachment. All operations of the PARABOLA/TPMS, except for raising and lowering the boom, are controlled from the PARABOLA data system control panel. For the FIFE experiments, the PARABOLA instrument was attached to a boom supported by a tripod which positioned the radiometer head at 4m above the ground.

Source/Platform Mission Objectives:

Rapid acquisition of bi-directional observations of the land and atmosphere, by measurement of the angular distributions of reflected radiation of natural earth surface targets. Its specific purpose was to provide bi-directional reflectance measurements of the various prairie cover types.

Key Variables:

Radiances, reflectance, and viewing angle.

Principles of Operation:

The scan system is designed such that sampling is done in a continuous helical pattern. The data is recorded serially in digital form. There is also a "calibrate"/hold position (mode) that allows

manual pointing of the detector head for individual measurements of calibration sources in any direction. In the helical sampling mode a complete data set can be taken in 11 seconds followed by a 35 second data dump to the tape recorder from the buffer. Approximately 50 data sets can be stored on one digital cassette tape.

Sensor/Instrument Measurement Geometry:

The PARABOLA design provides multidirectional viewing, but the geometry of the system does not allow the same "spot" on the ground to be measured at each view direction. Thus, target surfaces that are homogeneous over relatively large areas are sampled with replication. A minimum of three complete replicate scans are acquired for each data set using a special boom rotation technique to minimize any within-field heterogeneity effects and improve the sensitivity to angular reflectance features of the surfaces. The 15 degrees sensor IFOV provides "viewing areas" that are quite large relative to the spatial structure of the surfaces measured within the various pixels; ranging from approximately 2 square meters at nadir to approximately 17 square meters at 60 degree off-nadir angle.

Manufacturer of Sensor/Instrument:

Biospheric Sciences Branch
NASA/Goddard Space Flight Center
Greenbelt, MD 20771

Calibration:

LABORATORY CALIBRATION:

Radiometric laboratory calibration of the PARABOLA were performed at NASA Goddard Space Flight Center on a 1.8 m spherical integrator employing 12 200-W quartz halogen lamps (2950 K at 6.5 A). The number of lamps illuminating the sphere is varied to produce 12 radiance levels for calibration.

FIELD CALIBRATION:

Radiometric Field Calibration of the PARABOLA were performed using a Barium sulfate painted reference standard panel. The field calibration of each channel on the PARABOLA instrument was necessary for the calculation of reflectance. Calibration measurements were taken at varying sun angles and then averaged.

Specifications:

LABORATORY CALIBRATION:

Three separate calibration runs are made to fully calibrate the PARABOLA at the three gain levels. Neutral density filters (0.1 and 0.01 density levels) are used for the two lowest gain

settings. The voltage response to radiance level relationship is linear in all three spectral channels for each gain setting with linear correlation coefficients of 0.999[rE2].

FIELD CALIBRATION:

Not available at this revision.

Tolerance:

LABORATORY CALIBRATION:

Calibrations performed after one full year of use and testing (May 1982-May 1983) showed no significant change in voltage output for the same radiance levels, which indicates the stability of the total PARABOLA system.

Frequency of Calibration:

LABORATORY CALIBRATION:

Laboratory calibrations are made once or twice a year, depending on field experiment schedule.

FIELD CALIBRATION:

Not available at this revision.

Other Calibration Information:

FIELD CALIBRATION:

Dr. Deering supplied calibrated radiances for use in reflectance computations. The calibration measurements were done on a Barium sulfate painted reference standard panel. All calibrated radiances where corrected for sun-angle (anisotropy). FIS personnel multiplied the calibrated radiances by 10 to convert the units to [Watt][m^-2][sr^-1][um^-1]. These calibrated radiances are listed in the following table:

OBS_DATE	TIME	SITEGRID	STN	SZA	CAL_BAND1	CAL_BAND2	CAL_BAND3
06-JUN-87	1436	1916-PAR	2	50.9	298.39	196.17	44.83
06-JUN-87	1729	1916-PAR	2	20.3	437.89	287.29	66.4
11-JUL-87	1455	2132-PAR	6	48.8	296.78	178.21	45.07
11-JUL-87	2015	2043-PAR	44	27.8	400.87	239.73	61.57
15-AUG-87	1342	2655-PAR	36	67.4	179.89	118.67	27.7
15-AUG-87	1421	2655-PAR	36	59.9	232.95	152.75	35.94
15-AUG-87	1519	2655-PAR	36	48.9	303.5	198.06	46.9
15-AUG-87	1618	2655-PAR	36	38.4	360.68	234.79	55.78
15-AUG-87	1642	2655-PAR	36	34.6	378.54	246.26	58.56
15-AUG-87	1711	2655-PAR	36	30.5	395.96	257.45	61.27
15-AUG-87	1745	2655-PAR	36	26.9	409.62	266.22	63.39
15-AUG-87	1913	2132-PAR	6	26.6	411.92	255.32	64.05
15-AUG-87	2019	2132-PAR	6	34.5	377.25	233.09	58.88
15-AUG-87	2048	2132-PAR	6	39.1	353.45	217.82	55.33

15-AUG-87	2208	2132-PAR	6	53.6	263.04	159.83	41.83
15-AUG-87	2248	2132-PAR	6	61.3	207	123.89	33.47
15-AUG-87	2339	2132-PAR	6	71.2	128.81	73.74	21.8
11-OCT-87	1512	2731-PAR	4	62.1	231.55	145.17	34.24
11-OCT-87	1801	2731-PAR	4	46.1	351.66	223.47	51.04
11-OCT-87	1939	2731-PAR	4	50.2	332.73	215.75	47.74
11-OCT-87	2036	2731-PAR	4	56.8	289.53	188.16	41.92
11-OCT-87	2211	2731-PAR	4	71.7	150.11	98.52	23.11
04-AUG-89	1411	2133-PAR	906	60.2	216	132.75	35.24
04-AUG-89	1638	2133-PAR	906	33.1	372.22	234.37	60.5
04-AUG-89	1812	2133-PAR	906	22.2	412.64	260.66	67.04
04-AUG-89	2303	2133-PAR	906	62.0	199.68	125.03	33.94
08-AUG-89	1302	4439-PAR	916	74.1	112.24	74.23	19.23
08-AUG-89	1339	4439-PAR	916	67.0	167.04	111.01	28.02
08-AUG-89	1423	4439-PAR	916	58.5	228.88	152.52	37.95
08-AUG-89	1503	4439-PAR	916	50.8	280.28	187.02	46.21
08-AUG-89	1548	4439-PAR	916	42.4	330.23	220.55	54.22
08-AUG-89	1640	4439-PAR	916	33.5	375.02	250.61	61.41

5. Data Acquisition Methods:

Data was acquired from the PARABOLA instrument mounted atop a 4 meter boom. The boom was located within the field site so that the collected data would be representative of the surface being studied. The standard method of data collection was to take measurements in sequence with the movement of the solar principal plane axis. To increase the sampling density, on some occasions measurements were taken with the radiometer boom rotated by + and - 7.5 degrees from the solar principal plane axis. This added two additional scans which were averaged with the solar principle plan scan (see the *Data Processing Sequence Section* for details).

6. Observations:

Data Notes:

Not available.

Field Notes:

Not available at this revision.

7. Data Description:

Spatial Characteristics:

The FIFE study area, with areal extent of 15 km by 15 km, is located south of the Tuttle Reservoir and Kansas River, and about 10 km from Manhattan, Kansas, USA. The northwest corner of the area has UTM coordinates of 4,334,000 Northing and 705,000 Easting in UTM Zone 14.

Spatial Coverage:

The PARABOLA data was collected at the following locations:

SITEGRID_ID	STATION_ID	NORTHING	EASTING	LATITUDE	LONGITUDE	ELEVATION
1916-PAR	2	4330296	708270	39 05 56	-96 35 30	340
2731-PAR	4	4328678	711110	39 05 01	-96 33 34	446
2132-PAR	6	4329774	711336	39 05 36	-96 33 23	405
2655-PAR	36	4328787	716070	39 05 00	-96 30 07	367
2043-PAR	44	4330003	713536	39 05 42	-96 31 51	415
2133-PAR	906	4329726	711604	39 05 34	-96 33 12	443

Spatial Coverage Map:

Not available.

Spatial Resolution:

Ranges from 2 square meter at nadir to 5.7 square meter at a 45 degrees off-nadir angle, to 17 square meters at 60 degrees of nadir.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

The overall time period of PARABOLA data acquisition was from June 6, 1987 through October 11, 1987 and on August 4, 1989.

Temporal Coverage Map:

Not available.

Temporal Resolution:

Data were collected at intervals during the daylight hours. The PARABOLA measures a 4 pi hemisphere area with 15 degree IFOV sectors in 11 seconds.

Data Characteristics:

The SQL definition for this table is found in the PARABOLA.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.			FIS
STATION_ID	The station ID designating the location of the observations.			FIS
OBS_DATE	The date of the observations.			FIS
OBS_TIME	The time of these observations.	min = 30, max = 2355, missing = -9999	[GMT]	FIS
NUM_OBS	The number of data points used for the averaged data listed. A negative number means the measurement was shadowed, and data was taken from the opposite side. A zero means interpolated data.			
SOLAR_ZEN_ANG	The Solar Zenith Angle, which is		[degrees]	

the vertical angle of the sun from zenith. Zero degrees is straight up and 90 degrees is on the horizon.		
SOLAR_AZIM_ANG The Solar Azimuth Angle, which is the horizontal angle of the sun from north. Zero degrees is north and 90 degrees is east.	[degrees from North]	
GEOGRAPH_VIEW_ZEN_ANG This value is the average angle from the surface normal (straight up) to the observing instrument. The PARABOLA is looking at GROUND when the angle is 0 to 90 and at SKY when the angle is 90 to 180.	[degrees]	FIS
GEOGRAPH_VIEW_AZIM_ANG The average View Azimuth Angle, which is the horizontal angle of the measurement from north. Zero degrees is north and 90 degrees is east.	[degrees from North]	FIS
HEMIS_ID The type of observation, GROUND or SKY.		FIS
BAND1_RADNC The radiance value for band 1 (0.65 to 0.67 microns). [ster^-1] [mic^-1]	[Watts] [meter^-2]	
BAND2_RADNC The radiance value for band 2 (0.81 to 0.84 microns). [ster^-1] [mic^-1]	[Watts] [meter^-2]	
BAND3_RADNC The radiance value for band 3 (1.62 to 1.69 microns). [ster^-1] [mic^-1]	[Watts] [meter^-2]	

BAND1_REFL The reflectance factor for band 1 (0.65 to 0.67 microns).		[percent]	FIS
BAND2_REFL The reflectance factor for band 2 (0.81 to 0.84 microns).		[percent]	FIS
BAND3_REFL The reflectance factor for band 3 (1.62 to 1.69 microns).		[percent]	FIS
BIN_VIEW_ZEN_ANG The View Zenith Angle of bin center where the data value was assigned. Bin values range from 0 to 75; use HEMIS_ID to determine which hemisphere the data is in.		[degrees]	
BIN_VIEW_AZIM_ANG The View Azimuth Angle of bin center where the data value was assigned. This value ranges from 0 to 360 degrees, where the sun is at zero and backscatter direction is at 180 degrees.		[degrees from North]	
PRNCPL_PLN_VIEW_ZEN_ANG The average View Zenith Angle of the values falling in the bin. Values range from 0 to 90; use HEMIS_ID to determine which hemisphere the data is in.		[degrees]	
PRNCPL_PLN_VIEW_AZIM_ANG The average View Azimuth Angle of the values falling in the bin. Values ranges from 0 to 360 degrees, where the sun is at zero and backscatter direction is at 180 degrees.		[degrees from North]	
FIFE_DATA_CRTFCN_CODE The FIFE Certification Code for the data, in the following format: CPI (Certified by PI), CPI-??? (CPI - questionable data).	CPI - checked by primary investigator		FIS
LAST_REVISION_DATE			

data, in the format (DD-MMM-YY).

Footnote:

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_ID	STATION_ID	OBS_DATE	OBS_TIME	NUM_OBS	SOLAR_ZEN_ANG
2132-PAR	6	15-AUG-87	2339	2	71.17
2132-PAR	6	15-AUG-87	2339	3	71.17
2132-PAR	6	15-AUG-87	2339	-2	71.17
2132-PAR	6	15-AUG-87	2339		71.17

SOLAR_AZIM_ANG	GEOGRAPH_VIEW_ZEN_ANG	GEOGRAPH_VIEW_AZIM_ANG	HEMIS_ID
273.05	150.00	278.85	SKY
273.05	134.40	280.15	SKY
273.05	119.30	283.05	SKY
273.05	105.00	273.05	SKY

BAND1_RADNC	BAND2_RADNC	BAND3_RADNC	BAND1_REFL	BAND2_REFL	BAND3_REFL
25.01	11.05	2.32	19.416	14.985	10.642
49.97	22.24	8.77	38.794	30.160	40.229
204.38	86.87	13.07	158.668	117.806	59.954
358.80	151.50	17.38	278.550	205.452	79.725

BIN_VIEW_ZEN_ANG	BIN_VIEW_AZIM_ANG	PRNCPL_PLN_VIEW_ZEN_ANG
30.00	360.00	30.00
45.00	360.00	45.60
60.00	360.00	60.70
75.00	360.00	75.00

PRNCPL_PLN_VIEW_AZIM_ANG	FIFE_DATA_CRTFCN_CODE	LAST_REVISION_DATE
354.20	CPI	01-APR-92
352.90	CPI	01-APR-92
350.00	CPI	01-APR-92
360.00	CPI	01-APR-92

8. Data Organization:

Data Granularity:

The overall time period of PARABOLA data acquisition was from June 6, 1987 through October 11, 1987 and on August 4, 1989. Data were collected at intervals during the daylight hours.

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:

The three columns BAND1_REFL, BAND2_REFL, and BAND3_REFL were calculated by FIS personnel. This was done by taking the Barium sulfate painted reference standard panel calibration information supplied by Dr. Deering, and using the following formula:

REF_CHAN_x = (RADIANCE_CHAN_x / BaSO4 calib for channel x) * 100

Where **x** is channel number and the calibration panel radiances are given in the *Other Calibration Information Section*.

Data Processing Sequence:

Processing Steps:

For more spatially heterogeneous sites three or more (*n*) complete replicate scans are occasionally acquired by moving the instrument within the site. The replicates are averaged for

each viewing angle position to minimize the within-field heterogeneity effects. The average of the *n* values is taken as the canopy radiance for a particular view direction. Directional reflectances are normally computed as hemispherical-directional reflectance factors using the PARABOLA directional radiance measurements from the ground-looking hemisphere divided by the PARABOLA-derived incidence irradiance as computed from the PARABOLA sky irradiance data or from a calibrated Barium Sulfate painted reference standard panel.

The solar principle plane scan and the two scans which were + and 7.5 degrees (see the *Data Acquisition Methods Section*) from the solar principle plane are combined in a special program that has been written to analyze the bi-directional reflectance distribution characteristics of the site. This procedure also enables more accurate sampling of the "hot spot" effects and the aureole surrounding the solar disk.

Since the PARABOLA observations are not acquired at equal angles of azimuth and zenith, and since most users prefer the data at equal intervals, this data has been averaged into standard bins.

A data aggregation scheme was established which defines bins of 30 degrees of azimuth and 15 degrees of zenith for each of the sky and ground hemispheres, resulting in (360 / 30) * (90 / 15) bins (i.e., 12 * 6 = 76 bins) per hemisphere. The observed pixels falling in a given bin were averaged to derive the supplied radiance value. The number of pixels used in computing the bin average is contained in the column NUM_OBS. Data gaps resulting from the scanning pattern, shadowing or contamination of the pixel by instrument support equipment or operators, and/or other anomalies are handled as follows.

- If data is available from the opposite side of the hemisphere, the data gap is filled by substituting the opposite information into the empty area. Note that this assumes symmetry in the azimuth plane with respect to the solar principal plane. These instances are identified with a negative number of observations in the last column of the file records.
- If no data is available from the opposite side of the hemisphere, an interpolated value is used. These instances are identified with a zero in the number of observations column.

FIS Processing Steps PARABOLA data:

1. Inventoried all original data sets by date, time, and site.
2. Manipulated the received PARABOLA data into a standard coordinate reference systems.
3. FIS computed the solar zenith angles and solar azimuth angles based on site location, observation date, and observation time.
4. FIS created new view azimuth values (GEOGRAPH_VIEW_AZIM_ANG) in the PARABOLA data set so that 0 (zero) degrees is for N, 90 is for E, 180 is for S, and 270 is for W. This was changed from the original reference (PRNCPL_PLN_VIEW_ZEN_ANG) of zero degrees being directly at the sun by calculating the solar position based on site location, observation date, and observation time and then rotating the values.

5. Reflectance factors were calculated from radiance values by taking the Barium sulfate painted reference standard panel calibration information supplied by Dr. Deering (see the *Derivation Techniques and Algorithms Section* for details).

Processing Changes:

Not available at this revision.

Calculations:

Special Corrections/Adjustments:

Not available at this revision.

Calculated Variables:

Not available at this revision.

Graphs and Plots:

Not available at this revision.

10. Errors:

Sources of Error:

Not available at this revision.

Quality Assessment:

Data Validation by Source:

Not available at this revision.

Confidence Level/Accuracy Judgment:

Not available at this revision.

Measurement Error for Parameters:

Not available at this revision.

Additional Quality Assessments:

FIS staff applied a general QA procedure to the data to identify inconsistencies and problems for potential users. As a general procedure, the FIS QA consisted of examining the maximum, minimum, average, and standard deviation for each numerical field in the data table. In some cases, histograms were examined to determine whether outliers were consistent with the shape of the data distribution. Inconsistencies and problems found in the QA check are described is the *Known Problems with the Data Section*.

Data Verification by Data Center:

The data verification performed by the ORNL DAAC deals with the quality of the data format, media, and readability. The ORNL DAAC does not make an assessment of the quality of the data itself except during the course of performing other QA procedures as described below.

The FIFE data were transferred to the ORNL DAAC via CD-ROM. These CD-ROMs are distributed by the ORNL DAAC unmodified as a set or in individual volumes, as requested. In addition, the DAAC has incorporated each of the 98 FIFE tabular datasets from the CD-ROMs into its online data holdings. Incorporation of these data involved the following steps:

- Copying the entire FIFE Volume 1, maintaining the directory structure on the CD-ROM;
- Using data files, documentation, and SQL code provided on the CD-ROM to create a database in Statistical Analysis System (SAS); 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 of the revision data of this document, the following discrepancies or errors in the data have been reported:

Results of the FIS staff quality assessments:

The two sets of readings, listed below, are outside the documented time ranges and are at extreme sun angles.

SITEGRID_ID	STATION_ID	OBS_DATE	OBS_TIME
2731-PAR	4	15-AUG-87	1342 and 2339

The data at 1342 (GMT) and 2339 (GMT) on August 15, 1987 should be used with caution. It was very early and very late in the day. Hence solar zenith angles were high.

Usage Guidance:

Before using the PARABOLA data, it is recommended that Deering and Leone (1986) be read.

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 the variation in vegetation reflectance as a function of solar and sensor viewing geometry, wavelength, and plant canopy biophysical characteristics.

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 Reflectances Measured by the PARABOLA are available on FIFE CD-ROM Volume 1. The CD-ROM filename is as follows:

\DATA\SUR_REFL\PARABOLA\Yyyyy\ydddgrid.PAR

Where *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 .PAR for this data set.

17. References:

Satellite/Instrument/Data Processing Documentation.

Deering, D.W., and P. Leone. 1986. A sphere-scanning radiometer for rapid directional measurements of sky and ground radiance. Remote Sens. Environ. 19:1-24.

Journal Articles and Study Reports.

Ahmad, S.P., E.M. Middleton and D.W. Deering. 1987. Computation of Diffuse Sky Irradiance from Multidirectional Radiance Measurements. Remote Sens. Environ. 21:185-200.

Deering, D.W., and T.F. Eck. 1987. Atmospheric Optical Depth Effects on Angular Anisotropy of Plant Canopy Reflectance. Int. J. Remote Sens. 8:893-916.

Deering, D.W. 1989. Field Measurements of Bi-directional Reflectance. In: Theory and Applications of Optical Remote Sensing. John Wiley & Sons, Inc. pp. 14-65.

Deering, D.W., T.F. Eck and J. Otterman. 1990. Bi-directional Reflectances of Three Desert Surfaces and Their Characterization Through Model Inversion. J. Agric. and Forest Meteorol. 52:71-93.

Deering, D.W., E.M. Middleton, J.R. Irons, B.L. Blad, E.A. Walter-Shea, C.J. Hays, C.W. Walthall, T.F. Eck, S.P. Ahmad, and B.P. Banerjee. 1992. Prairie Grassland Bi-directional Reflectance Measured by Different Instruments at the FIFE Site. 97:18,887-18,903.

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.

Leshkevich, G.A., D.W. Deering, T.F. Eck and S.P. Ahmad. 1990. Diurnal Patterns of the Bi-directional Reflectance of Freshwater Ice. Annals of Glaciol. 14:153-157.

Middleton, E.M., D.W. Deering and S.P. Ahmad. 1987. Surface Anisotropy and Hemispheric Reflectance of Semi-Arid Plant Communities. Remote Sens. Environ. 23:193-212.

Otterman, J., D.W. Deering, and T.F. Eck. 1987. Techniques of Ground- Truth Measurements of Desert-Scrub Structure. Advances in Space Res. 7:153-158.

Shephard, M.K., R.E. Arvidson, E.A. Guinness and D.W. Deering. 1991. Application of Hapke Photometric Model to Lunar Lake Playa Using PARABOLA Bi-directional Reflectance Data. Geophys. Res. Letters 18:2241-2244.

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:

BRDF Bi-directional Reflectance Distribution Function DAAC Distributed Active Archive Center EOSDIS Earth Observing System Data and Information System FIFE First ISLSCP Field

Experiment FIS FIFE Information System GMT Greenwich Mean Time IFOV Instantaneous Field of View ISLSCP International Satellite Land Surface Climatology Project ORNL Oak Ridge National Laboratory PARABOLA Portable Apparatus for Rapid Acquisition of Bi-directional Observations of the Land and Atmosphere SZA Solar Zenith Angle URL Uniform Resource Locator

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

20. Document Information:

May 4, 1994 (citation revised on October 16, 2002).

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.

Document Review Date:

August 14, 1996.

Document ID:

ORNL-FIFE_PARABOLA.

Citation:

Cite this data set as follows:

Deering, D. W., and E. Middleton. 1994. PARABOLA Data (FIFE). Data set. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/68. Also published in D. E. Strebel, D. R. Landis, K. F. Huemmrich, and B. W. Meeson (eds.), Collected Data of the First ISLSCP Field Experiment, Vol. 1: Surface Observations and Non-Image Data Sets. CD-ROM. National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland, U.S.A. (available from http://www.daac.ornl.gov).

Document Curator:
DAAC Staff
Document URL:
http://daac.ornl.gov