Satellite SPOT Extracted Data (FIFE)

Summary:

The Site Reflectances Extracted from SPOT HRV Imagery Data Set contains the average instrument corrected spectral radiances for each of the spectral bands (3 in XS and 1 in PAN) collected during the growing seasons of 1987, 1988, and 1989. In addition, the associated view angles and solar angles are available for each of 39 FIFE ground measurement sites. The data set also contains reflectances and exoatmospheric reflectances for these spectral bands. These reflectances were derived using the sensor calibrated radiance values corrected using atmospheric aerosol optical thickness and gaseous absorption profile measurements, when available. The atmospheric correction algorithm of Fraser et al. (1989) was used to calculate reflectance in the visible and infrared channels.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Satellite SPOT Extracted Data (FIFE)
(Site Reflectances Extracted from SPOT HRV Imagery)

Data Set Introduction:

The Site Reflectances Extracted from SPOT HRV Imagery Data Set contains the average instrument corrected spectral radiances for each of the spectral bands (3 in XS and 1 in PAN). In addition, the associated view angles and solar angles are available for each of 39 FIFE ground measurement sites. The data set also contains reflectances and exoatmospheric reflectances for these spectral bands.

Objective/Purpose:

The FIFE Staff Science effort covered those activities that were FIFE community-level activities, or required uniform data collection procedures across sites and time. These activities included acquiring and processing data from the High Resolution Visible (HRV) instruments on the SPOT satellites.

As part of the FIFE staff science data collection effort, the FIFE Information System (FIS) extracted site reflectances from the level-1 SPOT multispectral (XS) and panchromatic (PAN) data.

Summary of Parameters:

Site specific radiance, exoatmospheric reflectance, and surface reflectance for the three multispectral (XS) and one panchromatic bands.

Discussion:

The site reflectances extracted from SPOT HRV data contain the average instrument corrected spectral radiances (in [Watts][meter^-2][steradian^-1][micrometer^-1]) for each of the spectral bands (3 in XS and 1 in PAN). In addition, the associated view angles and solar angles are available for each of 39 FIFE ground measurement sites. The data set also contains reflectances and exoatmospheric reflectances for these spectral bands. These reflectances were derived using the sensor calibrated radiance values corrected using atmospheric aerosol optical thickness and gaseous absorption profile measurements, when available. The atmospheric correction algorithm of Fraser et al. (1989) was used to calculate reflectance in the visible and infrared channels. The extracts are available about once every days to 10 two weeks during the growing seasons of 1987, 1988, and 1989.

Related Data Sets:

- Level 3 Normalized Difference Vegetation Index (NDVI) Images from SPOT. (Imagery data)
- SPOT High Resolution Visible (HRV) Averages. (Imagery data)
- Site Reflectances Extracted from Landsat TM Imagery.
- Site Average Reflectances Extracted from AVHRR-LAC Imagery.
- Satellite Image Value Conversion Coefficients.
- Daily and Site Radiation Flux Averages Derived from GOES.

FIS Data Base Table Name:

SATELLITE_EXTRACT_SPOT_DATA.

2. Investigator(s):

Investigator(s) Name and Title:

Staff Science.

Title of Investigation:

Staff Science Satellite Data Acquisition Program.

Contact Information:

Contact 1:
Jeffrey A. Newcomer
NASA/Goddard Sp. Fl. Ctr.
Greenbelt, MD.
(301) 286-7858
newcomer@ltp.gsfc.nasa.gov

Requested Form of Acknowledgment.

The Site Reflectance from SPOT HRV Imagery were extracted by the FIFE Information System staff. The dedicated work of Scott Goetz and Jeff Newcomer is especially appreciated.

3. Theory of Measurements:

The SPOT (Systeme Pour l'Observation de la Terre) satellite system provides capability of applying high resolution multispectral imagery to a range of land use and land cover analyses. The SPOT satellite is equipped with two HRV (High Resolution Visible) linear array (pushbroom) sensors capable of operating in a panchromatic (PAN) mode with 10-m resolution, or a three-band multispectral (XS) mode with 20-m resolution.

Thematic considerations dictated, within technical constraints, the choice of spectral band position and width in the multispectral mode. Three bands were selected for the multispectral mode:

1. A green (500 to 590 nm) band centered at the 550 nm maximum in the chlorophyll reflectance curve. This band is on the long wavelength side of the broad attenuation minimum of water, thus giving access to turbidity assessment and bathymetric evaluation in the first 10 to 20 m of surface water;

2. A red band (610 to 680 nm), similar to the channel on Landsat Thematic Mapper, provides much information on crop identification, bare soil, and rocky surfaces. Atmospheric transmittance on a clear day is about 90 percent while water penetration is about 2 m with surface reflectance of 4% (attenuation coefficient: 5x10E-1 [m^-1]). This band corresponds to a chlorophyll absorption, i.e., low vegetation reflectance.
3. The near infrared band (790 to 890) is one that penetrates best through the atmosphere (Transmittance is about 95 percent for a clear atmosphere model) and light haze. Vegetation stands out brightly and water surfaces appear very dark (1% reflectance with a high attenuation coefficient: 10 to 50 per m). Although silicon spectral sensitivity extends out to 1100 nm, the band was not extended beyond 900 nm in order to avoid response modulation by atmospheric water vapor and limit the smearing effect of electron diffusion within the detectors (Chevrel et al., 1981).

For the higher ground resolution black-and-white (so called panchromatic) mode, a broader spectral band was required. In order to retain the capability for texture analysis in support of the color mode and a high information content over vegetated areas, the interval 510 to 730 nm was chosen for the broad band.

4. Equipment:

Sensor/Instrument Description:

The High Resolution Visible sensor system used to collect the original data from which this data set was produced has been described in detail in the document describing the SPOT High Resolution Visible (HRV) Averages. See that document for a detailed description of this sensor system.

Collection Environment:

See the *Sensor/Instrument Description Section*.

Source/Platform:

See the *Sensor/Instrument Description Section*.

Source/Platform Mission Objectives:

See the *Sensor/Instrument Description Section*.

Key Variables:

See the *Sensor/Instrument Description Section*.

Principles of Operation:

See the *Sensor/Instrument Description Section*.

Sensor/Instrument Measurement Geometry:

See the *Sensor/Instrument Description Section*.

Manufacturer of Sensor/Instrument:

See the *Sensor/Instrument Description Section*.

Calibration:

Specifications:

See the *Sensor/Instrument Description Section*.

Tolerance:

See the *Sensor/Instrument Description Section*.

Frequency of Calibration:

See the *Sensor/Instrument Description Section*.

Other Calibration Information:

See the *Sensor/Instrument Description Section*.

5. Data Acquisition Methods:

The SPOT site reflectances were extracted from the FIFE level-1 HRV data by FIFE staff at Goddard Space Flight Center. Members of the staff selected pixels from SPOT HRV Level-1 Images that overlaid specific stations within the FIFE study area. The original imagery from the High Resolution Visible instruments on the SPOT satellites were acquired from the SPOT Image Corporation, Reston, Virginia.

6. Observations:

Data Notes:

Not available.

Field Notes:

None.

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 data were extracted from the images at 40 different locations scattered throughout the FIFE study area. The exact locations of the extracted pixels are given below:

SITEGRID	NORTHING	EASTING	LATITUDE	LONGITUDE	ELEV	SLOPE	ASPECT
0847-SPT	4332344	714439	39 06 57	-96 31 11	418	1	TOP
1246-SPT	4331625	714200	39 06 34	-96 31 22	410	12	S
1445-SPT	4331160	714090	39 06 19	-96 31 27	400		
1478-SPT	4331223	720664	39 06 15	-96 26 53	375	2	N
1563-SPT	4331100	717610	39 06 14	-96 29 01	366	18	W
1916-SPT	4330282	708259	39 05 55	-96 35 30	351	2	
1935-SPT	4330195	711927	39 05 49	-96 32 58	425	20	N
1942-SPT	4330133	713414	39 05 46	-96 31 56	422	1	TOP
2043-SPT	4329952	713679	39 05 40	-96 31 45	415		
2123-SPT	4329866	709506	39 05 41	-96 34 39	405	1	TOP
2133-SPT	4329706	711577	39 05 34	-96 33 13	443	1	TOP
2139-SPT	4329843	712789	39 05 37	-96 32 23	3		
2330-SPT	4329314	711066	39 05 22	-96 33 35	424	5	E
2428-SPT	4329265	710635	39 05 20	-96 33 53	415		
2516-SPT	4328956	708102	39 05 12	-96 35 38	405		
2655-SPT	4328787	716070	39 05 00	-96 30 07	367	4	E
2731-SPT	4328678	711110	39 05 01	-96 33 34	446		
2915-SPT	4328167	708028	39 04 47	-96 35 42	415		
3021-SPT	4328000	709250	39 04 40	-96 34 52	410	11	NW
3129-SPT	4327822	710820	39 04 33	-96 33 47	431	14	E
3221-SPT	4327682	709112	39 04 30	-96 34 58	410		
3317-SPT	4327395	708485	39 04 22	-96 35 24	427	15	W
3409-SPT	4327244	706850	39 04 18	-96 36 32	420	12	E
3414-SPT	4327286	707854	39 04 19	-96 35 51	410		
3479-SPT	4327134	720890	39 04 02	-96 26 49	420		
3921-SPT	4326116	709185	39 03 39	-96 34 57	415		
4139-SPT	4325850	712780	39 03 28	-96 32 27	385	3	W
4268-SPT	4325630	718500	39 03 16	-96 28 30	420	1	TOP
4439-SPT	4325193	712773	39 03 06	-96 32 28	443	2	N
4509-SPT	4324960	706850	39 03 04	-96 36 35	390	3	SE
4609-SPT	4324890	706705	39 03 02	-96 36 41	390		
5926-SPT	4322227	710270	39 01 32	-96 34 16	370		
6221-SPT	4321583	709247	39 01 12	-96 34 59	410		
6340-SPT	4321500	713000	39 01 07	-96 32 23	410	4	SW
6469-SPT	4321189	718752	39 00 51	-96 28 25	440	3	NE
6735-SPT	4320652	712073	39 00 40	-96 33 03	385	1	BOTTOM
6833-SPT	4320346	711660	39 00 30	-96 33 20	410		
6912-SPT	4320111	707336	39 00 26	-96 36 20	397	2	N
6943-SPT	4320147	713500	39 00 22	-96 32 04	415		
8739-SPT	4316699	712845	38 58 31	-96 32 35	442	1	TOP

Spatial Coverage Map:

Not available.

Spatial Resolution:

The multispectral data have a nadir IFOV of 20 m. The panchromatic data have a nadir IFOV of 10 m.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

FIFE SPOT HRV image acquisition used for extract products covers the period from March 20, 1987 through August 9, 1989. There are no data for December 1987 - March 1988, and from November 1988 - May 1989.

Temporal Coverage Map:

Not available.

Temporal Resolution:

The SPOT satellite orbit and pointable sensors make it possible to acquire images as little as one day apart. During the FIFE IFCs, an attempt was made to obtain as many cloud free images as possible. In addition, monitoring data were obtained at least monthly through the growing season of all 3 years of FIFE. Extracts are available about once every 10 days to two weeks during the overall coverage given above.

Data Characteristics:

The SQL definition for this table is found in the SAT_SPOT.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 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 (expressed as DD-MMM-YY), on which the image data was recorded.			
OBS_TIME The time (GMT) when the data at the center of the level-1 image were collected.			
IMAGE_ID The FIS image identification code for the level-1 satellite image from which the site statistics were derived.			
PLATFORM The satellite platform on which the data collecting instrument is mounted.			
INSTR_ID The instrument which collected the image data.			
NUM_OBS The number of observations (pixels) found within the site coordinate boundaries and used in the statistics calculations.			

MIN_LAT The minimum latitude of all the pixels extracted from the level-1 image and used to derive the site statistics (expressed as DD MM SS.SS).		
MAX_LAT The maximum latitude of all the pixels extracted from the level-1 image and used to derive the site statistics (expressed as DD MM SS.SS).		
MIN_LON The minimum longitude of all the pixels extracted from the level-1 image and used to derive the site statistics (expressed as DDD MM SS.SS).		
MAX_LON The maximum longitude of all the pixels extracted from the level-1 image and used to derive the site statistics (expressed as DDD MM SS.SS).		
VIEW_ZEN_ANG The view zenith at the center of the site.		[degrees]
VIEW_AZIM_ANG The view azimuth at the center of the site (North = 0, East = 90, South = 180, West = 270).		[degrees from North]
SOLAR_ZEN_ANG The solar zenith at the center of the site.		[degrees]
SOLAR_AZIM_ANG The solar azimuth at the center of the site (North = 0, East = 90, South = 180, West = 270).		[degrees from North]
BAND1_AVG_RADNC The average radiance over the	$$	[Watts]

site for band 1 of the designated sensor.		[meter^-2]
BAND1_SDEV_RADNC The standard deviation of the radiance values over the site for band 1 of the designated sensor.	*, $$	[Watts] [meter^-2]
BAND2_AVG_RADNC The average radiance over the site for band 2 of the designated sensor.	$$	[Watts] [meter^-2]
BAND2_SDEV_RADNC The standard deviation of the radiance values over the site for band 2 of the designated sensor.	*, $$	[Watts] [meter^-2]
BAND3_AVG_RADNC The average radiance over the site for band 3 of the designated sensor.	$$	[Watts] [meter^-2]
BAND3_SDEV_RADNC The standard deviation of the radiance values over the site for band 3 of the designated sensor.	*, $$	[Watts] [meter^-2]
BAND1_AVG_REFL The average reflectance over the site for band 1 of the designated sensor.	$$	[percent]
BAND2_AVG_REFL The average reflectance over the site for band 2 of the designated sensor.	$$	[percent]
BAND1_EXOATMOSIC_REFL The at-satellite reflectance for band 1 of the sensor, calculated as observed reflected radiance divided by the solar irradiance at the top of the atmosphere.	$$	[percent]
BAND2_EXOATMOSIC_REFL The at-satellite reflectance for band 2 of the sensor, calculated	$$	[percent]

```
as observed reflected radiance
divided by the solar irradiance at
the top of the atmosphere.
```

```
BAND3_EXOATMOSIC_REFL                          $$
The at-satellite reflectance for                        [percent]
band 3 of the sensor, calculated
as observed reflected radiance
divided by the solar irradiance at
the top of the atmosphere.
```

```
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:

$$ When the IMAGE_ID begins with "SX", Bands 1, 2, and 3 are used for multispectral data. When the IMAGE_ID begins with "SP", only Band 1 has data. Bands 2 and 3 are null.

* The missing value indicator is -99.

** 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 which 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	IMAGE_ID	PLATFORM
4509-SPT	817	08-JUN-89	1729	SX043-1	SPOT1
4609-SPT	22	08-JUN-89	1729	SX043-1	SPOT1
5926-SPT	15	08-JUN-89	1729	SX043-1	SPOT1
8739-SPT	26	08-JUN-89	1729	SX043-1	SPOT1

INSTR_ID	NUM_OBS	MIN_LAT	MAX_LAT	MIN_LON
HRV1	4	39 03 04.45	39 03 05.22	-96 36 36.00

HRV1	5	39 03 01.44	39 03 02.34	-96 36 38.75
HRV1	6	39 01 31.75	39 01 33.14	-96 34 11.59
HRV1	5	38 58 20.09	38 58 21.50	-96 32 26.75

MAX_LON	VIEW_ZEN_ANG	VIEW_AZIM_ANG	SOLAR_ZEN_ANG	SOLAR_AZIM_ANG
-96 36 34.97	8.6	281.9	20.1	139.7
-96 36 37.13	8.6	281.9	20.1	139.7
-96 34 10.31	8.9	281.9	20.1	139.7
-96 32 25.72	9.3	281.9	20.0	139.7

BAND1_AVG_RADNC	BAND1_SDEV_RADNC	BAND2_AVG_RADNC	BAND2_SDEV_RADNC
65.342	.4888	53.139	.5235
65.782	1.0726	53.610	.8757
62.813	1.4409	53.401	1.7521
54.035	.8189	38.742	1.0472

BAND3_AVG_RADNC	BAND3_SDEV_RADNC	BAND1_AVG_REFL	BAND2_AVG_REFL
69.893	1.1007	9.4	10.4
74.846	.7778	9.5	10.5
58.520	1.8957	8.9	10.5
71.544	1.3476	6.9	6.8

BAND1_EXOATMOSIC_REFL	BAND2_EXOATMOSIC_REFL	BAND3_EXOATMOSIC_REFL
11.9	11.2	22.2
12.0	11.3	23.8
11.5	11.3	18.6
9.9	8.2	22.7

FIFE_DATA_CERTFN_CODE	LAST_REVISION_DATE
CPI	09-JAN-91
CPI	09-JAN-91
CPI	09-JAN-91
CPI	09-JAN-91

8. Data Organization:

Data Granularity:

The data were extracted from the images at 40 different locations scattered throughout the FIFE study area. The multispectral data have a nadir IFOV of 20 m. The panchromatic data have a nadir IFOV of 10 m.

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 procedure used to calculate SPOT atmospherically corrected reflectance was developed at GSFC as part of the FIFE staff science effort. The images were calculated from FIFE level-1 data and the reflectance and atmospheric correction calculations were performed using data and information available in the FIFE data collection.

Sensor calibrated radiances for the SPOT HRV images were converted to surface reflectance using the following procedures and information available in the FIFE satellite extracts coefficients data set.

1. Derive at-satellite radiance:

   The radiance values for the respective bands were calculated as follows:

   Radiance = (DN(I) - OFFSET(I))/GAIN(I)

   where:

   Radiance = spectral radiance for channel **I** [Watt][m^-2][sr^-1][um^-1]
   DN(I) = digital number for channel **I** [counts]
   OFFSET(I) = sensor offset for channel **I** [counts]
   GAIN(I) = sensor gain for channel **I** [counts][radiance unit^-1]

   a) OFFSET Determination

   The offset variable values used were those supplied on the data tapes from SPOT Image Corporation. These values to date on all tapes acquired for FIFE, have been equal to 0.0 (zero).

   b) GAIN Determination

The gain variable values used are calculated from the gain settings supplied on the data tape, a set of absolute calibration coefficients obtained from SPOT Image Corporation, and the following equation:

GAIN(i) = CC(i) * [1.3(Gs(i) - 3)]**

where:

GAIN(i) = the gain value for band **i**.
CC(i) = the absolute calibration coefficient for band **i** supplied by SPOT Image Corporation.
Gs(i) = the gain setting obtained from the data tape.

The following table contains the values for **CC(i)** for several dates since launch (February 1986) for the SPOT 1 satellite. **CC(i)** values for images acquired between these dates are linearly interpolated from this table.

		HRV1				HRV2		
DATE	**PAN**	**XS1**	**XS2**	**XS3**	**PAN**	**XS1**	**XS2**	**XS3**
24-FEB-86	0.604	0.558	0.422	0.629	0.604	0.568	0.463	0.644
20-MAR-86	0.605	0.550	0.405	0.608	0.605	0.560	0.445	0.623
20-JUN-86	0.598	0.536	0.388	0.589	0.598	0.541	0.428	0.606
20-MAR-87	0.592	0.510	0.363	0.563	0.582	0.512	0.407	0.586
20-SEP-87	0.583	0.496	0.353	0.554	0.574	0.498	0.400	0.580
15-MAR-88	0.577	0.485	0.344	0.547	0.567	0.484	0.392	0.574
20-AUG-88	0.572	0.479	0.342	0.544	0.563	0.480	0.389	0.572
20-DEC-88	0.568	0.473	0.338	0.541	0.558	0.473	0.385	0.569
20-APR-89	0.564	0.466	0.335	0.538	0.553	0.468	0.381	0.567
20-AUG-89	0.561	0.461	0.332	0.536	0.549	0.462	0.378	0.566
20-DEC-89	0.556	0.454	0.329	0.534	0.543	0.454	0.375	0.566

2. Convert to exoatmospheric reflectance (**L'm**) for each band:

L'm = (PI * Lm) / (F'o * cos(szen)

where (an apostrophe indicates a subscript):

Lm = apparent at-satellite calibrated spectral radiance [mWatt][m^-2][sr^-1][um^-1]
F'o = Fo / (R^2)
R = d / d'
d = earth-sun distance (astronomical units)
d' = average earth-sun distance =1 astronomical unit
szen = solar zenith angle (degrees)
Fo = extraterrestrial solar irradiance in the HRV and PAN bandpasses as listed below:

	HRV1	**HRV2**	**PAN**	
Band1	1884.0	1873.0	1689.0	[Watt][m^-2][um^-1]
Band2	1635.0	1590.0	-	
Band3	1084.0	1039.0	-	

3. Calculate surface reflectance (rho) for each band:

   rho = f / (1 + s * f)

   where:

   s = backscattering ratio (column BSCAT in the satellite extract coefficients data set)
   f = (L'm - L'o) / (F'd* T)
   L'm = from (2) above
   F'd = normalized surface flux (column IRRAD in the satellite extract coefficients data set)
   L'o = normalized path radiance (column PATH_RAD in the satellite extract coefficients data set)
   T = path transmission (column TRANS in the satellite extract coefficients data set)

The final site radiances and reflectances are averaged over the site and the mean and standard deviation for each channel is reported.

Data Processing Sequence:

Processing Steps:

FIFE staff creates the average instrument corrected spectral radiance data by :

1. Enumerating the pixel and line coordinates of the pixels that fall within each of the 39 sites.
2. Extracting the spectral, geographic, viewing, and solar information for the enumerated pixels.
3. Converting and correcting the digital spectral counts to radiance.

FIFE staff creates the reflectance data by :

1. Extracting the date, time, station_id, level-1a sensor calibrated radiances, solar zenith angles, view zenith angles, and observation height information from the FIS, for all dates, sites, and SPOT visible and IR channels.
2. Correcting the apparent at-sensor radiances for Earth-Sun distance and solar zenith angle by converting them to exoatmospheric (top of the atmosphere) reflectances, calculated as described in Fraser et al., (1989), and in Markham and Barker (1986).
3. Extracting optical thickness measurements from the FIS for the variety of instruments that collected such data, and calculating the aerosol optical thickness for the SPOT-channel wavelengths. Optical thickness measurements are interpolated to the SPOT channels using a linear fit of the log of wavelength regressed against the log of optical thickness. SPOT-channel model wavelengths are calculated as described in Fraser et al., (1989). For the acquisitions in which no optical thickness measurements were available, a

default value calculated from the median of all such measurements taken in 1988 and 1989 is used. The default values used are 0.14, 0.12, 0.08, for SPOT channels 1-3 respectively, and 0.12 for the panchromatic channel.

4. Calculating default extinction coefficients (optical thicknesses) due to water vapor and other gas (carbon dioxide and ozone) absorption from the Lowtran7 mid-latitude summer model. The default values calculated are listed below (the quantities are dimensionless):

	HRV1		HRV2		PAN
	Water	Other	Water	Other	
Band1	0.00740	0.02526	0.00451	0.02732	0.01610	0.02738
Band2	0.01319	0.02881	0.01720	0.02456	-	-
Band3	0.04908	0.00849	0.05362	0.00127	-	-

5. Calculating ground level downward irradiance, upward radiance, and surface reflectance in the SPOT channels for each of the sites in each acquisition using the algorithm of Fraser et al., (1989) and all the atmospheric, geometric, and radiometric data from above. The algorithm also outputs coefficients that allow conversion of any other portion of the scene to be corrected to surface reflectance. These coefficients are included in the satellite coefficients data set.

Processing Changes:

None.

Calculations:

Special Corrections/Adjustments:

None.

Calculated Variables:

- Radiance,
- Gain,
- Exoatmospheric reflectance,
- Surface reflectance,
- Averaged final site radiances and reflectances,
- Mean and standard deviation for each channel,
- Default extinction coefficients (optical thicknesses), and
- Ground level downward irradiance, upward radiance, and surface reflectance.

Graphs and Plots:

None.

10. Errors:

Sources of Error:

Errors could arise in the acquired imagery due to location accuracy, distortion of lengths, anisomorphism, the instrument's local coherence, the ability to register multispectral data, and relief plotting accuracy. Other errors could arise from inherent radiometric imperfections of the sensors. Spectral errors arise due to image wide signal-to-noise ratio, saturation, cross-talk, spikes, response normalization due to change in gain.

Whatever the processing level, the geometric quality of the image depends on, a) the accuracy of the viewing geometry, and b) the ground control points as required to adjust the viewing model. Errors arise from the processing of the data to level-1A due to calibration inaccuracies (gains and offsets/drift of sensor characteristics/optical degradation), and resampling/positioning in geometric corrections.

Quality Assessment:

Data Validation by Source:

The FIFE staff was responsible for screening imagery for quality, applying radiometric corrections, computing geometric corrections corresponding to the required map projection, applying geometric corrections, and screening for cloud cover on imagery during processing.

Confidence Level/Accuracy Judgment:

The precision of satellite remote sensing estimates of surface reflectance (Hall et al., 1992), calibrated and corrected for atmospheric effects, was no worse than about 1 percent absolute. The errors may actually be smaller, but an upper bound of 1 percent results from sampling variance caused by differences among the satellite and ground sensors in spatial resolution, atmospheric effects, and calibration.

Measurement Error for Parameters:

The magnitude of the errors described in the *Sources of Error Section* is unknown.

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, histograms 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:

or errors in the data have been reported. For each band a number of unusually high values have been identified in the average reflectances, average radiances and exoatmospheric reflectances. Those values above the indicated threshold (given in the table below) should be used with caution.

Band	Parameter	Number of Encountered	Threshold	Maximum Value
BAND1	AVG_REFL	24	20	
BAND1	AVG_RADNC	28	100	MAX 280
BAND1	EXOATMOSIC_REFL	25	20	MAX 50+
BAND2	AVG_REFL	21	20	
BAND2	AVG_RADNC	20	90	MAX 239
BAND2	EXOATMOSIC_REFL	15	25	MAX 50+
BAND3	AVG_REFL	14	50	
BAND3	AVG_RADNC	5	150	MAX 185
BAND3	EXOATMOSIC_REFL	5	50	
BAND4	AVG_REFL	1	12	

Only a few of the SPOT images caused the majority of the spikes noted above. Those images are listed below and of those, three (marked with an '&' below) are associated with the highest spikes.

IMAGE_ID	OBS_DATE
SX006-1 &	01-JUN-87
SX009-1 &	11-JUN-87
SX012-1	18-JUL-87
SX013-1	18-JUL-87
SX014-1	23-JUL-87
SX029-1	13-APR-88

SX033-1 & 05-JUL-88

Usage Guidance:

The SPOT extract data collected for FIFE may be useful for establishing relationships with biophysical and geophysical variables on the Earth's surface, and for comparison with other prairie landscapes.

Any Other Relevant Information about the Study:

None.

12. Application of the Data Set:

The Site Reflectances Extracted from SPOT HRV Imagery Data Set may be useful for establishing relationships with biophysical and geophysical variables on the Earth's surface, and for comparison with other prairie landscapes.

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:

Site Reflectances Extracted from SPOT HRV Imagery are available on FIFE CD-ROM Volume 1. The CD-ROM file name is as follows:

\DATA\SAT_OBS\Yyyyy\ydddFIFE.SPT

Where *yyyy* are the four digits of the year (e.g., 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: *ydddFIFE.sfx*, *y* is the last digit of the year (e.g., 7 = 1987, and 9 = 1989), and *ddd* is the day of the year (061 = sixty-first day of the year). The filename extension (.*sfx*), identifies the data set content for the file (see the *Data Characteristics Section*) and is equal to .SPT for this data set.

17. References:

Satellite/Instrument/Data Processing Documentation.

Kneizys, F.X., E.P. Shettle, W.O. Gallery, J.H. Chetwynd, L.W. Abreu, J.E.A. Selby, S.A. Clough, and R.W. Fenn. 1988. Atmospheric transmittance/radiance: computer code LOWTRAN-7, AFGL-TR-88-0177. Air Force Geophysics Lab. Hanscomb AFB, Massachusetts.

Newcomer, J.A., S.J. Goetz, D.E. Strebel, and F.G. Hall. 1989. Image processing software for providing radiometric inputs to land surface climatology models. IGARSS '89, 12th Can. Symp. on Remote Sensing. pp. 1779-1782.

Journal Articles and Study Reports.

Asrar, G., R Murphy, F. Hall, and P Sellers. 1991. Use of multitemporal SPOT data in First ISLSCP Field Experiment. Proc. 5th Intl. Colloquium. Courchevel, France. 14-18 January.

Boissin, B., and J. Perbos. 1985. SPOT image quality and post launch assessment. Advanced Space Res. 5:51-60.

Carper, J.W., T.M. Lillesand, and R.W. Kiefer. 1990. The use of intensity-hue-saturation transformations for merging SPOT panchromatic and multispectral image data. Photogr. Engr. and Rem. Sen. 56:459-467.

Chavez, P.S.,Jr., and J.A. Bowell. 1988. Comparison of the spectral information content of Landsat Thematic Mapper and SPOT for three different sites in the Phoenix, Arizona, Region. Photogr. Engr. and Rem. Sen. 54:1699-1708.

Chevrel, M., M. Courtois, and G. Weill. 1981. The SPOT satellite remote sensing mission. Photogr. Engr. and Rem. Sens. 47:1163-1171.

Fraser, R. S., R. A. Ferrare, Y. J. Kaufman, and S. Mattoo. 1989. Algorithm for atmospheric corrections of aircraft and satellite imagery. NASA Technical Memorandum 100751. 106p.

Hall, F.G., D.E. Strebel, J.E. Nickeson, and S.J. Goetz. 1991. Radiometric Rectification: Toward a Common Radiometric Response Among Multidate, Multisensor Images. Remote Sens. Environ. 35:11-27.

Hall, F.G., K.F. Huemmrich, S.J. Goetz, P.J. Sellers, and J.E. Nickeson. 1992. Satellite remote sensing of surface energy balance: success, failures, and unresolved issues in FIFE. J. Geophys. Res. 97:19061-19089.

Markham, B.L., and J.L. Baker. 1986. Landsat MSS and TM post-calibration dynamic ranges, exoatmospheric reflectances and at-satellite temperatures. EOSAT Landsat Tech. Notes 1:3-7. Lanham, Maryland.

Welch, R., and M. Ehlers. 1987. Merging multiresolution SPOT HRV and Landsat TM data. Photogr. Engr. and Rem. Sen. 53:301-305.

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:

ASCII American Standard Coded Information Interchange BPI Byte per inch CCT Computer Compatible Tape 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 GMT Greenwich Mean Time HRV High Resolution Visible ISLSCP International Satellite Land Surface Climatology Project ORNL Oak Ridge National Laboratory SPOT Systeme Pour l'Observation de la Terre URL Uniform Resource Locator UTM Universal Transverse Mercator

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

20. Document Information:

April 26, 1994 (citation revised on October 14, 2002).

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

Document Review Date:

September 4, 1996.

Document ID:

ORNL-FIFE_SAT_SPOT.

Citation:

Cite this data set as follows:

Newcomer, J. A. 1994. Satellite SPOT Extracted 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/79. 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