NS001 TMS Extracted Data (FIFE)

Summary:

As part of the FIFE staff science data processing effort, the FIFE Information System (FIS) extracted site average radiances from the level-1 NS001-TMS products. Data were collected by the NS001 during each of the FIFE IFC's. Selected flights were processed to level-1. The site averages were extracted from these processed images. Therefore, this data set contains a small number of observation dates for each site, but at the multiple angles provided by the "grid" pattern used during each flight. The data set can be used for canopy reflectance modeling studies.

The site average radiances extracted from the NS001 imagery are instrument-corrected spectral radiances for each of the eight spectral bands. Geographic location and viewing and solar angles for each of 39 FIFE ground measurement sites are also included for each observation. The sensor calibrated radiance values were 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 thermal data are corrected using parameters derived from the Lowtran7 atmospheric path radiance model (Kneizys et al., 1988).

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1. Data Set Overview:

Data Set Identification:

NS001 TMS Extracted Data (FIFE)
(Site Reflectances Extracted from NS001 Imagery)

Data Set Introduction:

The Site Reflectances Extracted from NS001 Imagery Data Set contains a small number of observation dates for each site, but at the multiple angles provided by the "grid" pattern used during each flight. The data set contains site specific radiance and apparent surface temperatures.

Objective/Purpose:

The FIFE Staff Science effort covered those activities which would have been community level activities, or required uniform data collection procedures across sites and time, hence, would be activities more appropriate to a team than to individual investigators. These included the acquisition of data from NASA's NS001 sensor flown on a C130 aircraft managed by Ames Research Center.

As part of the FIFE staff science data processing effort, the FIFE Information System (FIS) extracted site average radiances from the level-1 NS001-TMS products.

Summary of Parameters:

Site specific radiance, and apparent surface temperature.

Discussion:

The site average radiances extracted from the NS001 imagery are instrument-corrected spectral radiances for each of the eight spectral bands. Geographic location and viewing and solar angles for each of 39 FIFE ground measurement sites are also included for each observation. The sensor calibrated radiance values were 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 thermal data are corrected using parameters derived from the Lowtran7 atmospheric path radiance model (Kneizys et al., 1988).

Data were collected by the NS001 during each of the FIFE IFC's. Selected flights were processed to level-1. The site averages were extracted from these processed images. Therefore, this data set contains a small number of observation dates for each site, but at the multiple angles provided by the "grid" pattern used during each flight. The data set should be useful for canopy reflectance modeling studies.

Related Data Sets:

- Landsat Thematic Mapper (TM) Averages. (Imagery data)

- FIFE Level-3 Multispectral Atmospheric Mapping Sensor (MAMS). (Imagery data)
- FIFE Level-1 NS001 Thematic Mapper Simulator (TMS). (Imagery data)
- FIFE Level-2 NS001 Atmospherically Corrected Radiances and Surface Temperatures. (Imagery data)
- Sunphotometer Optical Thickness Data from C130 Aircraft.
- SPOT High Resolution Visible (HRV) Averages. (Imagery data)
- FIFE Level-1 Advanced Solid-state Array Spectroradiometer (ASAS) Imagery. (Imagery data)

FIS Data Base Table Name:

NS001_TMS_EXTRACT_DATA.

2. Investigator(s):

Investigator(s) Name and Title:

Staff Science.

Title of Investigation:

Staff Science Satellite Data Acquisition Program.

Contact Information:

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Requested Form of Acknowledgment.

The NS001 site reflectances were extracted from the FIFE Level-1 NS001 imagery by the FIFE Information System staff at Goddard Space Flight Center. The work of Mr. Scott Goetz and Ms. Brenda Colesanti is particularly appreciated.

3. Theory of Measurements:

The NASA Earth Resources Aircraft program at Ames Research Center operates the C-130 aircraft to acquire data for Earth science research. The NS001 Multi-spectral Scanner used on the C130 aircraft collects radiance measurements in the seven Landsat-4 and -5 Thematic Mapper (TM) bands plus a band from 1000 to 1300 nm. Therefore, when reflected or emitted radiation from Earth surface features are measured from the aircraft, inferences can be made about Landsat satellite measurements.

Thematic considerations have dictated, within technical constraints, the choice of spectral band position and width in the Landsat and NS001 sensors. The eight bands were chosen after many years of analysis for their value in discrimination of several Earth surface features. A blue (450 to 520 nm) band provides increased penetration of water bodies as well as supporting analyses of land use, soil, and vegetation characteristics. The lower-wavelength cutoff is just below the peak transmittance of clear water, while the upper-wavelength cutoff is the limit of chlorophyll absorption in the blue region of the electromagnetic spectrum for healthy green vegetation. Wavelengths below 450 nm are substantially influenced by atmospheric scattering and absorption.

A green (520 to 600 nm) band spans the region between the blue and red chlorophyll absorption bands, and therefore corresponds to the green reflectance of healthy vegetation. A red (630 to 690 nm) band includes the chlorophyll absorption band of healthy green vegetation and represents one of the most important bands for vegetation discrimination. The latter is also useful for soil boundary and geological boundary delineation. A reflective-infrared (760 to 900 nm) band is especially responsive to the amount of vegetation biomass present in a scene. It is useful for crop identification and emphasizes soil-crop and land-water contrasts.

Finally, the thermal infrared band (10.4 to 12.5 um) measures the amount of infrared radiant flux emitted from surfaces. The apparent temperature is a function of the emissivities and true or kinetic temperature of the surface. It is useful for locating geothermal activity, thermal inertia mapping for geologic investigations, energy balance estimation, evapotranspiration characteristics, vegetation stress analysis, and soil moisture studies.

4. Equipment:

Sensor/Instrument Description:

The Thematic Mapper Sensor system used to collect the original data from which this data set was produced has been described in detail in the document FIFE Level-1 NS001 Thematic Mapper Simulator (TMS) contained on FIFE CD-ROM Volume 1.

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 NS001 instrument was flown on NASA's C-130 aircraft during FIFE (see the FIFE Experiment Plan or the FIFE Interim Report for flight pattern details and objectives). The FIFE

Information System (FIS) staff processed 8-band NS001 Thematic Mapper Simulator (TMS) multispectral scanner data to FIFE level-1 products. (See the document entitled FIFE Level-1 NS001 Thematic Mapper Simulator (TMS) data for a description of these products.)

6. Observations:

Data Notes:

Not available.

Field Notes:

Printed flight summary reports produced by Ames Research Center include the pilot's comments. Other flight notes are available as verbal records on video tapes. These materials are available at the archive (see the *Data Center Identification Section*).

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:

Image coverage was dependent upon the type of mission flown (e.g., Coordinated Mission Plan (CMP) 1, 2, or 3, see FIFE Experiment Plan). In the FIFE, only high level grid flights, with altitudes ranging from 3313 to 8146 meters, were processed to level 1, and subsequently to level 2. NS001 data were collected at the 4878 meter altitude during 1987 on flight lines that were approximately 3.5 km apart and 8 km wide. The flight lines were oriented perpendicular and parallel to the solar plane, ideally with three lines in each direction. This pattern covered the entire FIFE area, with multiple views (up to 6) of most of the central portion. The pattern, altitude, and spacing were modified somewhat in 1989, to provide intensive coverage of the three "super-sites" (see FIFE-89 Experiment Plan). The pixels extracted from the NS001 images overlay 61 stations located within 35 sitegrids scattered throughout the FIFE study area. The sitegrids and stations underlying these pixels are listed below.

SITEGRID_ID	STN_ID	SITEGRID_ID	STN_ID	SITEGRID_ID	STN_ID
0847-TMS	29	2139-TMS	31	4168-TMS	25
0847-TMS	929	2330-TMS	908	4168-TMS	925
1246-TMS	40	2428-TMS	3	4439-TMS	16
1246-TMS	940	2428-TMS	903	4439-TMS	916
1445-TMS	42	2516-TMS	14	4609-TMS	22
1445-TMS	942	2516-TMS	914	4609-TMS	922

1478-TMS	38	2655-TMS	36	5926-TMS	15
1478-TMS	938	2655-TMS	936	5926-TMS	915
1563-TMS	27	2731-TMS	4	6340-TMS	20
1563-TMS	927	2915-TMS	12	6340-TMS	920
1916-TMS	2	3129-TMS	8	6469-TMS	23
1916-TMS	902	3129-TMS	912	6469-TMS	923
1942-TMS	944	3221-TMS	7	6735-TMS	13
2043-TMS	44	3221-TMS	907	6735-TMS	913
2123-TMS	5	3317-TMS	910	6912-TMS	24
2123-TMS	905	3414-TMS	10	6912-TMS	924
2132-TMS	6	3479-TMS	34	6943-TMS	28
2133-TMS	60	3479-TMS	934	6943-TMS	928
2133-TMS	906	3921-TMS	9	8739-TMS	26
2133-TMS	931	3921-TMS	909	8739-TMS	926

Spatial Coverage Map:

Not available.

Spatial Resolution:

The NS001 IFOV provides a footprint of 12.2 meters at nadir at an altitude of 4878 meters (16000 feet). The high-level grid flights were flown at or near this altitude in 1987.

In 1989, the FIFE grid missions were flown at an altitude of 8077 meters (26500 feet), resulting in a nadir footprint size of 20.2 meters.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

The NS001 data were collected from the C130 during FIFE's five IFC's during 1987 and 1989. Extracted site radiances are available for two dates in each IFC except IFC-4:

04-JUN-87	10-JUL-87	11-OCT-87
06-JUN-87	15-AUG-87	04-AUG-89
28-JUN-87	17-AUG-87	11-AUG-89

Temporal Coverage Map:

Not available.

Temporal Resolution:

The grid-pattern flight lines are 10-20 minutes apart. The lines processed to level 1 average 20-30 minutes apart, depending on the day. Two grids, separated by 4 hours, were processed for August 15, 1987. On the day when pixels were extracted from the NS001 images there were 2 to 5 pixels for each station and each of these pixels were collected about twenty minutes apart from each other.

Data Characteristics:

The SQL definition for this table is found in the NS001TMS.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 FIS site identifier used to designate this site (details are in the FIFE_SITE_REF table).

OBS_DATE
The date (expressed as DD-MMM-YY), on which the image data was recorded.

OBS_TIME
The time (GMT) at the center of the level-1 image when the data were collected. [GMT]

IMAGE_ID
The image identifier that

identifies the FIS level-1 satellite image from which the site statistics were derived.		
NUM_OBS The number of observations (pixels) found within the site coordinate boundaries and used in the statistics calculations.		[pixels]
MIN_LAT The minimum latitude of all the pixels extracted from the level-1 image and used to derive the site statistics (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 (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 (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 (DDD MM SS.SS).		
CENTER_VIEW_ZEN_ANG The view zenith angle at the center of the site.		[degrees]
CENTER_VIEW_AZIM_ANG The view azimuth angle at the center of the site (North = 0, East = 90, South = 180, West = 270).		[degrees from North]
CENTER_SOLAR_ZEN_ANG The solar zenith angle at the center of the site.		[degrees]

CENTER_SOLAR_AZIM_ANG The solar azimuth angle at the center of the site (North = 0, East = 90, South = 180, West = 270).	[degrees from North]
BAND1_RADNC The average radiance over the site for TMS Band 1 (.458-.519 microns).	[Watts] [meter^-2]
BAND1_RADNC_SDEV The standard deviation of the radiance values over the site for TMS Band 1 (.458-.519 microns).	[Watts] [meter^-2]
BAND2_RADNC The average radiance over the site for TMS Band 2 (.529-.603 microns).	[Watts] [meter^-2]
BAND2_RADNC_SDEV The standard deviation of the radiance values over the site for TMS Band 2 (.529-.603 microns).	[Watts] [meter^-2]
BAND3_RADNC The average radiance over the site for TMS Band 3 (.633-.697 microns).	[Watts] [meter^-2]
BAND3_RADNC_SDEV The standard deviation of the radiance values over the site for TMS Band 3 (.633-.697 microns).	[Watts] [meter^-2]
BAND4_RADNC The average radiance over the site for TMS Band 4 (.767-.910 microns).	[Watts] [meter^-2]
BAND4_RADNC_SDEV The standard deviation of the radiance values over the site for TMS Band 4 (.767-.910 microns).	[Watts] [meter^-2]
BAND5_RADNC The average radiance over the	[Watts]

site for TMS Band 5 (1.13-1.35 microns).	[meter^-2]
BAND5_RADNC_SDEV The standard deviation of the radiance values over the site for TMS Band 5 (1.13-1.35 microns).	[Watts] [meter^-2]
BAND6_RADNC The average radiance over the site for TMS Band 6 (1.57-1.71 microns).	[Watts] [meter^-2]
BAND6_RADNC_SDEV The standard deviation of the radiance values over the site for TMS Band 6 (1.57-1.71 microns).	[Watts] [meter^-2]
BAND7_RADNC The average radiance over the site for TMS Band 7 (2.10-2.38 microns).	[Watts] [meter^-2]
BAND7_RADNC_SDEV The standard deviation of the radiance values over the site for TMS Band 7 (2.10-2.38 microns).	[Watts] [meter^-2]
BAND8_RADNC The average radiance over the site for TMS Band 8 (10.9-12.3 microns).	[Watts] [meter^-2]
BAND8_RADNC_SDEV The standard deviation of the radiance values over the site for TMS Band 8 (10.9-12.3 microns).	[Watts] [meter^-2]
BAND8_TEMP The average temperature over the site for TMS Band 8 (10.9-12.3 microns).	[degrees Celsius]
BAND8_TEMP_SDEV The standard deviation of the temperature values over the site for TMS Band 8 (10.9-12.3 microns).	[degrees Celsius]

```
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 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	IMAGE_ID	NUM_OBS
1916-TMS	2	17-AUG-87	2000	NS870619L4R1J-1	120
2428-TMS	3	17-AUG-87	2000	NS870619L4R1J-1	208
2731-TMS	4	17-AUG-87	2000	NS870619L4R1J-1	64
3221-TMS	7	15-AUG-87	1531	NS870614L3R1E-1	10

MIN_LAT	MAX_LAT	MIN_LON	MAX_LON	CENTER_VIEW_ZEN_ANG
39 05 52.94	39 05 59.02	-96 35 39.16	-96 35 32.56	14.9
39 05 18.83	39 05 27.80	-96 33 54.44	-96 33 43.63	32.4
39 04 57.75	39 05 02.41	-96 33 39.47	-96 33 33.50	32.3
39 04 30.56	39 04 32.13	-96 34 54.72	-96 34 52.38	35.6

CENTER_VIEW_AZIM_ANG	CENTER_SOLAR_ZEN_ANG	CENTER_SOLAR_AZIM_ANG	BAND1_RADNC
239.3	32.6	224.6	35.766
239.3	32.6	224.6	40.556
239.3	32.6	224.6	37.797
221.3	45.3	109.9	21.050

BAND1_RADNC_SDEV	BAND2_RADNC	BAND2_RADNC_SDEV	BAND3_RADNC	BAND3_RADNC_SDEV
1.2397	38.287	1.7649	33.718	2.5245
.8878	48.669	1.8404	38.383	1.8919
.9827	47.554	1.2760	35.636	1.9901
.3893	25.382	1.1843	19.822	.9865

BAND4_RADNC	BAND4_RADNC_SDEV	BAND5_RADNC	BAND5_RADNC_SDEV	BAND6_RADNC
55.038	4.4421	-99.000	.0000	13.851
91.634	5.4980	-99.000	.0000	14.375
93.334	2.9207	-99.000	.0000	13.262
54.597	5.8005	-99.000	.0000	8.827

BAND6_RADNC_SDEV	BAND7_RADNC	BAND7_RADNC_SDEV	BAND8_RADNC	BAND8_RADNC_SDEV
.7164	2.543	.1931	9.9221	.1732

.6432	2.297	.1616	9.6822	.1528
.5623	2.059	.1642	9.3804	.0737
.4354	1.297	.0989	9.4378	.0440

BAND8_TEMP	BAND8_TEMP_SDEV	FIFE_DATA_CRTFCN_CODE	LAST_REVISION_DATE
31.5	1.27	CPI	30-AUG-93
29.8	1.13	CPI	30-AUG-93
27.5	.55	CPI	30-AUG-93
27.9	.33	CPI	30-AUG-93

8. Data Organization:

Data Granularity:

NS001 data were collected at the 4878 meter altitude during 1987 on flight lines that were approximately 3.5 km apart and 8 km wide. The flight lines were oriented perpendicular and parallel to the solar plane, ideally with three lines in each direction. This pattern covered the entire FIFE area, with multiple views (up to 6) of most of the central portion. The pattern, altitude, and spacing were modified somewhat in 1989, to provide intensive coverage of the three "super-sites" (see FIFE-89 Experiment Plan). The pixels extracted from the NS001 images overlay 61 stations located within 35 sitegrids scattered throughout the FIFE study area.

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:

- Thermal Band apparent temperature:

  GSFC Gain (**G**) and Offset (**C**), as found in the header summary file(s), are calculated as follows:

  Calculate black body radiances, **Lw**([mWatts][centimeter^-2][steradian^-1][micrometer^-1]):
  (assume emissivity = 1) for BB1 and BB2 temperatures T(K)

  Example:

  Lw,bb1 = (K1 / (exp(K2/Tbb1)-1))

  where:

  K1 = 60.705 [mWatts][centimeter^-2][steradian^-1][micrometer^-1]
  K2 = 1258.39 [degrees K]

  K1,**K2** were "best fit" parameters or the temperature range of 273 - 323 K using the 8/87 NS001 spectral data and the Planck equation.

  b) **G = ((BB2 View - BB1 View) / (Lw,bb2 - Lw,bb1))**
  ([Counts][mWatts^-1][centimeter^2][steradian][micrometer])

  C = BB1 View - G * Lw,bb1 [counts]

- Target Radiance (Lw) can then be calculated as:

  (pixel value - C) / G

  and at-sensor apparent temperature as:

  T = K2 / ln(K1/Lw + 1)

Data Processing Sequence:

Processing Steps:

FIS created the level-1A data by:

1. Enumerating the pixel and line coordinates of the pixels that fall within the site locations as identified on a June 6, 1987 SPOT panchromatic reference image. The sites are each manually located because automated enumeration using image registration

transformations cannot adequately capture the distortions introduced to the imagery by aircraft motion.
2. Extracting the spectral, geographic, viewing, and solar information for the enumerated pixels.
3. Converting and correcting the digital spectral counts to radiance
4. Storing appropriate information in the data base.

Processing Changes:

Not available at this revision.

Calculations:

Special Corrections/Adjustments:

The NS001 internal integrating sphere is radiance calibrated in the laboratory and used as the in-flight reference for calibrating NS001 data. Documented here are the procedures used for FIFE data.

Laboratory Procedures:

1. Calculate the radiance of the laboratory source in the spectral band-passes of the instrument.
2. Measure the instrument response to at least two known radiance levels and determine the instrument gain and offset.
3. Transfer the calibration to the internal source.
4. Monitor the internal source calibration by reference to an external radiance source.

Data Processing Procedures:

1. Determine "in-flight" sensor gain and offset.
2. Apply the calibration to the field data.

To correct at-sensor values to apparent surface values, Lowtran7-calculated path radiance and transmission at 11 view zenith angles (-50, -40, -30, -20, -10, 0, +10, +20, +30, +40, and +50 degrees) are convolved with the NS001 thermal channel sensor response and are then linearly interpolated across the 100 degree scan angle of the instrument. These data are used to correct the at-sensor radiances to apparent atmospherically corrected surface radiances and then to surface temperature, on a pixel-by-pixel basis. The program that calculates the surface temperature scales the data from 0 - 255, with each count representing 0.2 degrees Celsius (for example, a count of 198 is 39.6 degrees C).

Calculated Variables:

- GSFC Gain and Offset,
- Atmospherically corrected surface radiances, and

- Surface temperature.

Graphs and Plots:

None.

10. Errors:

Sources of Error:

The NS001 data are calibrated in-flight by reference to the NS001 internal integrating sphere source. Apparent instabilities in this source or its monitoring circuitry, which are not fully understood, are the principal limiting factors in the absolute calibration of NS001 data. Uncertainties due solely to this behavior may reach 25% in 1987, though more typically are expected to be less than 15%. Other identified error sources at the 1-2% level for typical signals include dark current drift along the scan line, hysteresis-like sensitivity changes along the scan line, random noise, scan-speed-induced errors, and non-linearity of radiance with wavelength. Also, possible operator or human error could result due to gain/offset setting made by the crew to "optimize" instrument sensitivity for each flight line.

The NS001 optical system failed during IFC-2, resulting in early termination of that IFC. The diachronic lens was replaced at that time, potentially changing alignments in the optical system and changing calibration characteristics.

Polarization sensitivity of the NS001 was such that for typical atmospheric conditions, errors in channel 1 (0.45-0.52 um) radiances would be up to +/-10% and vary with scan angle; this progressively decreases with increasing wavelength (Markham and Ahmad 1990).

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.

Spectral errors could arise due to image wide signal-to-noise ratio, saturation, cross-talk, spikes, response normalization due to change in gain.

Quality Assessment:

Data Validation by Source:

The extracted FIFE site radiances have been used in several multiple-sensor calibration studies.

Confidence Level/Accuracy Judgment:

Ahmad and Markham (1992) have determined that the NS001 when scanning in the solar meridian plane, a typical condition for FIFE, produce radiance errors over a vegetated target of 10%, depending on the scanner orientations and sample number. When the radiances are

converted to surface reflectance, in the worst case a 1.5 to 4.5% surface reflectance value will result in a +/-45% error in reflectivity.

Measurement Error for Parameters:

The Noise Equivalent Spectral Radiance for the channels ranges from 0.08 to 2.77 micro watts per square cm. Uncertainties due to the behavior of the internal integrating sphere may have reached 25% in 1987, though more typically they are expected to be less than 15%. Random error in the NS001 mean reflectance data was primarily due to instrument noise, since the whole site is imaged and averaged. Instrumental noise is roughly 1 count, which translates to a 0.001 to 0.002 error in the mean retrieved reflectance.

Accuracy is plus or minus 1 degree in view zenith. View azimuth accuracy is dependent on the quality of onboard navigational data and aircraft tracking, and is probably no better than 2-3 degrees.

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:

During the general quality assessment carried out by the FIFE staff the following questionable data points were found. These data should be used with caution.

Variable	Date	Value
BAND1_RADNC	10-JUL-87	9 values < 0
BAND1_RADNC_SDEV	11-OCT, 6-JUN, & 10-JUL-87	13 values > 10
BAND2_RADNC	4-AUG-89	9 values > 100
BAND2_RADNC_SDEV	JUN 4, 6, & 28 1987, 10-JUL-87 & 4-AUG-89	51 values > 10
BAND4_RADNC	10-JUL-87	4 values < 0
BAND4_RADNC_SDEV	10-JUL-87, 15-AUG-87, 4,6,10-JUN-87	35 values > 1
BAND5_RADNC		ALL -99
BAND5_RADNC_SDEV		-99 <-> 0
BAND6_RADNC	4-JUN-87 Station 15	20.539
BAND7_RADNC	4-JUN-87 Station 15	4.627, 5.453
BAND8_TEMP	Peculiarly low values	4 values < 0

Footnotes:

Majority of the high readings were on this date.

In addition, these extract data have most of the problems encountered with the original level-1 NS001 data. These problems are detailed in the document entitled FIFE Level-1 NS001 Thematic Mapper Simulator (TMS). Consult that document if questions arise concerning an individual extract provided in this data set.

Usage Guidance:

The user should be aware that these radiance and temperature values are not calibrated to measure ground values for radiance or temperatures. Therefore, while they are useful in a relative sense for comparisons with in a scene, they may not be accurate where absolute radiances or temperatures are required. Comparisons with actual ground-acquired values should be made in such cases. See Markham et al. (1992);

Goetz et al. (1993, 1994) for validation results.

Any Other Relevant Information about the Study:

Two in-flight adjustments are made that affect the radiometric calibration of the reflective channels. The primary adjustment is to the post-amplifier gain of each channel. This is adjusted by means of a channel specific potentiometer before and between data acquisitions to optimize the spread of the data across the range of the A/D converter (8 bits). The gain settings are continuously variable and are not directly recorded in the data. They are inferred from changes in

the instrument response to the integrating sphere. The second adjustment is for scan speed, which is adjusted between 10 and 85 scans per second to maintain contiguous scan lines, or some multiple of contiguous if contiguity is not maintainable at the altitude required for data collection.

12. Application of the Data Set:

The Site Reflectances Extracted from NS001 Imagery Data Set should be useful for canopy reflectance modeling studies.

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 Site Reflectances Extracted from NS001 Imagery are available on FIFE CD-ROM Volume 1. The CD-ROM file name is as follows:

\DATA\SAT_OBS\NS001TMS\ydddMULT.TMS

Note: capital letters indicate fixed values that appear on the CD-ROM exactly as shown here, lowercase indicates characters (values) that change for each path and file.

The format used for the filenames is: *ydddMULT.sfx*, where *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 .TMS for this data set.

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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:

A/D Analog to Digital agl above ground level ARC Ames Research Center ASAS Advanced Solid-state Array Spectroradiometer BPI Byte per inch CCT Computer Compatible Tape CD-ROM Compact Disk (optical), Read-Only Memory CMP Coordinated Mission Plan 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 GSFC Goddard Space Flight Center IFC Intensive Field Campaign IFOV Instantaneous Field of View IR Infrared ISLSCP International Satellite Land Surface Climatology Project ORNL Oak Ridge National Laboratory PRT Precision Radiation Thermometer TM Thematic Mapper TMS Thematic Mapper Simulator URL Uniform Resource Locator UTM Universal Transverse Mercator

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

20. Document Information:

April 24, 1994 (citation revised on October 14, 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.

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