

# Satellite Atmos. Correction Coef. (FIFE)

## Summary:

The atmospheric effects on the transmitted and reflected solar radiation should be factored into the estimation of geophysical and biophysical parameters from remotely-sensed data, so that appropriate correction schemes can be employed to infer reflectivity of the ground from satellite radiometric data. Some of the correction techniques require derived coefficients as inputs in the algorithms that perform the atmospheric correction. As part of the FIFE staff science data collection effort, the FIFE Information System (FIS) utilized atmospheric correction and related algorithms to generate coefficients for deriving corrected values from the FIFE level-1 image products. These coefficients were used by FIFE staff in calculating site reflectances from pixel values extracted from the level-1 imagery.

The Fraser (Fraser et al., 1992) and LOWTRAN 7 (Kneizys et al., 1988) models were used for computation of coefficients used to correct radiances of scattered radiation measured by aircraft and/or satellite during FIFE. The Fraser algorithm is designed to compute the surface reflectance for a given measured radiance, or alternatively, the upward radiance at an arbitrary height when the surface reflectance is given. LOWTRAN 7 is a low-resolution propagation model and computer code for predicting atmospheric transmittance and background radiance from 0 to 50,000 [cm<sup>-1</sup>] at a resolution of 20 [cm<sup>-1</sup>].

## Table of Contents:

1. [Data Set Overview](#)
2. [Investigator\(s\)](#)
3. [Theory of Measurements](#)
4. [Equipment](#)
5. [Data Acquisition Methods](#)
6. [Observations](#)
7. [Data Description](#)
8. [Data Organization](#)
9. [Data Manipulations](#)
10. [Errors](#)
11. [Notes](#)
12. [Application of the Data Set](#)
13. [Future Modifications and Plans](#)
14. [Software](#)
15. [Data Access](#)
16. [Output Products and Availability](#)
17. [References](#)
18. [Glossary of Terms](#)
19. [List of Acronyms](#)
20. [Document Information](#)

# 1. Data Set Overview:

## Data Set Identification:

Satellite Atmos. Correction Coef. (FIFE)  
(Satellite Image Value Conversion Coefficients)

## Data Set Introduction:

The atmospheric effects on the transmitted and reflected solar radiation should be factored into the estimation of geophysical and biophysical parameters from remotely-sensed data, so that appropriate correction schemes can be employed to infer reflectivity of the ground from satellite radiometric data. The Satellite Image Value Conversion Coefficients Data Set contains the derived coefficients that are required as inputs in the algorithms that perform the atmospheric correction.

## 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 instruments on several satellites.

As part of the FIFE staff science data collection effort, the FIFE Information System (FIS) utilized atmospheric correction and related algorithms to generate coefficients for deriving corrected values from the FIFE level-1 image products. These coefficients were used by FIFE staff in calculating site reflectances from pixel values extracted from the level-1 imagery. See the documents entitled [Site Reflectances Extracted from Landsat TM Imagery](#), [Site Reflectances Extracted from SPOT HRV Imagery](#), and [Site Average Reflectances Extracted from AVHRR-LAC Imagery](#) for a discussion of the site reflectance calculation.

## Summary of Parameters:

Irradiance, transmittance, and effective wavelength.

## Discussion:

See the [Objective/Purpose Section](#).

## Related Data Sets:

- [Site Average Reflectances Extracted from AVHRR-LAC Imagery.](#)
- [Site Reflectances Extracted from SPOT HRV Imagery.](#)
- [Site Reflectances Extracted from Landsat TM Imagery.](#)
- Daily and Site Radiation Flux Averages Derived from GOES.

**FIS Data Base Table Name:**

SATELLITE\_EXTRACT\_COEFFS\_REF.

**2. Investigator(s):****Investigator(s) Name and Title:**

Staff Science.

**Title of Investigation:**

Staff Science Satellite Data Analysis Program.

**Contact Information:****Contact 1:**

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

**Contact 2:**

Scott Goetz  
NASA Goddard Sp. Fl. Ctr.  
Greenbelt, MD  
(301) 286-7858  
goetz@ltp.gsfc.nasa.gov

**Requested Form of Acknowledgment.**

The Satellite Image Value Conversion Coefficients were produced by the FIFE Information System staff. The dedicated work of Scott Goetz and Jeff Newcomer is especially appreciated.

**3. Theory of Measurements:**

The correction of remote sensing data acquired from satellites for effects due to the intervening atmosphere has proven to be a difficult problem. Not only does the atmosphere reduce the transmission of the incoming, reflected, and emitted radiation, but it contributes reflected and emitted radiation of its own. Under some conditions, atmospheric radiation comprises over 90% of the satellite-observed radiance, but even much smaller effects would degrade the quantitative use of these data unless they are taken into account.

Therefore, in estimating geophysical and biophysical parameters from remotely-sensed data, the atmospheric effects on the transmitted and reflected solar radiation should be factored into the analysis, so that appropriate correction schemes can be employed to infer reflectivity of the ground from satellite radiometric data. Some of the correction techniques require derived coefficients, as inputs in the algorithms that perform the atmospheric correction. The Fraser (Fraser et al., 1992) and LOWTRAN 7 (Kneizys et al., 1988) models were used for computation of coefficients used to correct radiances of scattered radiation measured by aircraft and/or satellite during FIFE.

The Fraser algorithm is designed to compute the surface reflectance for a given measured radiance, or alternatively, the upward radiance at an arbitrary height when the surface reflectance is given. The algorithm is applicable to many wavelengths in the visible and near-infrared spectrum (with appropriately specified gaseous absorption), for a wide range of solar and observation zenith angles, azimuth angles between the observer and the solar rays, and any height of the observer (aircraft or satellite). Any practical value of the aerosol optical thickness can be used, but the tabulated radiation parameters are computed for a specific aerosol size distribution and refractive indices. LOWTRAN 7 is a low-resolution propagation model and computer code for predicting atmospheric transmittance and background radiance from 0 to 50,000 [ $\text{cm}^{-1}$ ] at a resolution of 20 [ $\text{cm}^{-1}$ ].

## **4. Equipment:**

### **Sensor/Instrument Description:**

The Advanced Very High Resolution Radiometer (AVHRR), Thematic Mapper (TM), and the High Resolution Visible (HRV) sensor systems used to collect the original data from which this data set was produced have been described in detail for the Level-1 Advanced Very High Resolution Radiometer (AVHRR) Images, Landsat Thematic Mapper (TM) Averages, and FIFE SPOT High Resolution Visible (HRV) Averages data. See the individual documents describing those data sets for details.

### **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 satellite data conversion coefficients were produced for the FIFE level-1 satellite data by the FIS staff at Goddard Space Flight Center. A variety of algorithms were employed. The primary visible correction algorithm was developed by R.S. Fraser of GSFC under contract to FIFE. It is described in detail in the technical memorandum available in the Scanned Document subdirectory on FIFE CD-ROM Volume 1. In addition, the LOWTRAN 7 algorithm of Kneizys et al. (1988) was obtained from NTIS and the split window technique of Price (1983) was implemented. Auxiliary data such as visibility, atmospheric optical characteristics, and atmospheric water content were obtained from FIS.

## 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 calculated coefficients are applicable only to imagery acquired over the FIFE study area.

**Spatial Coverage Map:**

Not available.

**Spatial Resolution:**

The optical characteristics of the atmosphere vary on many scales. The satellite data conversion coefficients represent single-point theoretical calculations with no intrinsic spatial resolution.

**Projection:**

Not available.

**Grid Description:**

Not available.

**Temporal Characteristics:**

**Temporal Coverage:**

Correction coefficients were calculated for images acquired over the FIFE study area between February 3, 1987 and October 13, 1987.

**Temporal Coverage Map:**

Not available.

### Temporal Resolution:

The correction coefficients are calculated for a specific date and time at which there was a satellite overpass. They are only applicable for a period of a few hours centered on that time.

### Data Characteristics:

The SQL definition for this table is found in the SAT\_COEF.TDF file located on FIFE CD-ROM Volume 1.

---

#### Parameter/Variable Name

---

| Parameter/Variable<br>Source | Description   | Range                                | Units                                 |
|------------------------------|---|--------------------------------------|---------------------------------------|
| OBS_DATE                     | The date on which the image data were recorded.   | min = 10-FEB-87,<br>max = 13-OCT-89  | FIS                                   |
| OBS_TIME                     | The time at which the data at the center of the level-1 image were collected.                     | min = 1339,<br>max = 2221            | [GMT] FIS                             |
| IMAGE_ID                     | The image identification code for the FIS satellite image to which conversion coefficients apply. | min = 4215216345-1,<br>max = SX043-1 | FIS                                   |
| PLATFORM                     | The satellite platform on which the data collecting instrument is mounted.                        | min = LANDSAT-4,<br>max = SPOT1      | FIS                                   |
| INSTR_ID                     | The instrument which collected the image data.  | min = AVHRR-LAC,<br>max = TM         | FIS                                   |
| NORMLZD_PATH_RADNC           | The normalized path radiance, that is the upward radiance caused                                  | min = .0013,<br>max = 4.234          | [Watts]<br>[meter <sup>-2</sup> ] FIS |

solely by atmospheric scattering and emission, assuming zero surface reflectance. [ster^-1] [micrometer^-1]

---

IRRADNC  
The normalized downward solar flux (irradiance) through a horizontal surface at the ground. [micrometer^-1] min = .4599, [Watts] FIS max = .9267 [meter^-2] [ster^-1]

---

TRNSMTNC  
The fraction of the total irradiance (diffuse + direct) transmitted from the surface to the observer. min = .6805, FIS max = .9392

---

BACKSCAT\_RATIO  
The atmospheric backscattering ratio. min = .0042, FIS max = .2018

---

EFCTV\_WAVLEN  
The effective wavelength for a given sensor band response function, calculated as a function of surface reflectance, aerosol optical thickness, and geometry. min = .486, [microns] FIS max = 11.45

---

SOLAR\_ZEN\_ANG  
The solar zenith angle, i.e., the angle between lines drawn from the observed point a) vertically upward and b) to the sun position. min = 17.1, [degrees] FIS max = 78

---

CORRECTION\_MTHD  
The atmospheric correction method used to obtain the coefficients: the Fraser, et al. algorithm, Lowtran 7, or Split Window. FIS

---

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). max = 25-APR-91

---

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 modified certification codes currently in use 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:

| OBS_DATE           | OBS_TIME        | IMAGE_ID              | PLATFORM           | INSTR_ID     |  |  |  |  |  |
|--------------------|-----------------|-----------------------|--------------------|--------------|--|--|--|--|--|
| 08-MAY-87          | 2146            | LAC0912378N-1         | NOAA-9             | AVHRR-LAC    |  |  |  |  |  |
| 08-MAY-87          | 2146            | LAC0912378N-1         | NOAA-9             | AVHRR-LAC    |  |  |  |  |  |
| 09-MAY-87          | 2136            | LAC0912392N-1         | NOAA-9             | AVHRR-LAC    |  |  |  |  |  |
| 09-MAY-87          | 2136            | LAC0912392N-1         | NOAA-9             | AVHRR-LAC    |  |  |  |  |  |
| NORMLZD_PATH_RADNC | IRRADNC         | TRNSMTNC              | BACKSCAT_RATIO     | EFCTV_WAVLEN |  |  |  |  |  |
| .06710             | .85150          | .85230                | .08180             | .6390        |  |  |  |  |  |
| .02990             | .77520          | .77630                | .03250             | .8450        |  |  |  |  |  |
| .05260             | .85730          | .87910                | .08180             | .6390        |  |  |  |  |  |
| .02320             | .78290          | .81220                | .03250             | .8450        |  |  |  |  |  |
| SOLAR_ZEN_ANG      | CORRECTION_MTHD | FIFE_DATA_CRTFCN_CODE | LAST_REVISION_DATE |              |  |  |  |  |  |
| 49.400             | FRASER RTC      | CPI                   | 05-FEB-91          |              |  |  |  |  |  |
| 49.400             | FRASER RTC      | CPI                   | 05-FEB-91          |              |  |  |  |  |  |
| 47.200             | FRASER RTC      | CPI                   | 05-FEB-91          |              |  |  |  |  |  |
| 47.200             | FRASER RTC      | CPI                   | 05-FEB-91          |              |  |  |  |  |  |

## 8. Data Organization:

### Data Granularity:

Correction coefficients were calculated for images acquired over the FIFE study area between February 3, 1987 and October 13, 1987. The satellite data conversion coefficients represent single-point theoretical calculations with no intrinsic spatial resolution.

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:

Reflectance channel derivation using Fraser algorithm:

The relation between the measured radiance and the surface reflectance is expressed as a function of the path radiance, downward flux at the ground, atmospheric transmission, and the atmospheric backscattering ratio (Fraser et al., 1992). Using this relation, a lookup table is constructed, which relates the measured upward radiance to surface reflectance for several aerosol optical thicknesses, solar zenith angles, measurement wavelengths, and a range of observation directions. This lookup table is based on the tabulation of the results of radiative transfer computations that are made using a Dave (1972 a,b,c,d) code. It is assumed that the atmosphere and surface are horizontally homogeneous, and the surface reflects light according to Lambert's law. The light scattered by the atmosphere and the surface is assumed to be unpolarized. The atmosphere is also assumed to be cloud-free. For the most part, aerosol extinction is the dominant parameter in the aerosol component of the atmospheric effect (Fraser and Kaufman 1985). Thus, in this algorithm, the aerosol optical thickness is the only variable aerosol parameter. The algorithm uses a constant aerosol single scattering phase function and scattering albedo chosen to represent a rural environment. In the following, the mathematical basis of the algorithm is given. Details of applying it are discussed. Finally, an error analysis is made.

Thermal channel derivation using LOWTRAN 7 code:

The LOWTRAN 7 code calculates atmospheric transmittance, atmospheric background radiance, single scattered solar and lunar radiance, direct solar irradiance, and multiple scattered solar and thermal radiance. The spectral resolution of the model is 20 [cm<sup>-1</sup>] (full width at half maximum) in steps of 5 [cm<sup>-1</sup>] from 0 to 50,000 [cm<sup>-1</sup>] (0.2 um to infinity). The code uses a single-parameter band mode for molecular absorption, and includes the effects of continuum

absorption, molecular scattering, and aerosol extinction. Refraction and Earth curvature are considered in the calculation of an atmospheric slant path and attenuation amounts along the path. The code contains representative atmospheric, aerosol, cloud, and rain models, which are provided with the option to replace them with user-provided theoretical or measured values.

The angular scattering of light by the atmosphere is specified by the phase function that gives the differential probability of the scattered radiation going in a given direction. The scattering by the aerosols and air molecules are treated separately using the appropriate phase function for each. The angular distribution from the two types of scattering are combined, weighted by the corresponding scattering coefficients.

The single scattering approximation is valid over a broad range of conditions found in the atmosphere. However, there are also conditions of interest in the atmosphere where multiple scattering and/or internal sources must be included to accurately calculate the atmospheric radiance. There is no simple indicator that predicts the conditions for which the single solar scattering approximation is acceptable; rather the range of applicability depends upon a large set of parameters including the atmospheric profile, the optical path, the solar geometry, the aerosol phase function, and the wave-number region.

## **Data Processing Sequence:**

### **Processing Steps:**

FIFE staff creates the satellite extract coefficients 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 satellite 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 variety of instruments that collected such data, and calculating the aerosol optical thickness for the channel wavelengths. Optical thickness measurements are interpolated to the satellite channels using a linear fit of the log of wavelength regressed against the log of optical thickness. Satellite 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 were 0.14, 0.12, 0.08, for SPOT channels 1-3 respectively, and 0.12 for the panchromatic channel; 0.18, 0.14, 0.12, 0.09, 0.04, 0.03 for TM channels 1-7 respectively, excluding channel 6 (thermal).
4. Calculating default extinction coefficients (optical thicknesses) due to water vapor and other gas (carbon dioxide and ozone) absorption from the LOWTRAN 7 mid-latitude summer model. The default values calculated are listed below for the respective instruments.

**Default Atmospheric Optical Thicknesses**  
(all quantities are dimensionless)

| <b>AVHRR-LAC</b> | <b>Aerosols</b>   |              | <b>Water</b> |              | <b>Other gases</b> |              |            |
|------------------|-------------------|--------------|--------------|--------------|--------------------|--------------|------------|
| -----            | -----             | -----        | -----        | -----        | -----              | -----        |            |
| Channel-1        | 0.15              | 0.0208       | 0.0208       | 0.0247       |                    |              |            |
| Channel-2        | 0.10              | 0.1156       | 0.1156       | 0.0152       |                    |              |            |
|                  | <b>Landsat-TM</b> |              | <b>Water</b> |              | <b>Other</b>       |              |            |
|                  | -----             | -----        | -----        | -----        | -----              | -----        |            |
| Band1            | 0.00000           | 0.00671      | 0.00671      |              |                    |              |            |
| Band2            | 0.00020           | 0.03194      | 0.03194      |              |                    |              |            |
| Band3            | 0.00673           | 0.01829      | 0.01829      |              |                    |              |            |
| Band4            | 0.05011           | 0.00339      | 0.00339      |              |                    |              |            |
| Band5            | 0.12750           | 0.00849      | 0.00849      |              |                    |              |            |
| Band7            | 0.09722           | 0.00792      | 0.00792      |              |                    |              |            |
|                  |                   |              | <b>HRV1</b>  |              | <b>HRV2</b>        |              | <b>PAN</b> |
|                  | <b>Water</b>      | <b>Other</b> | <b>Water</b> | <b>Other</b> | <b>Water</b>       | <b>Other</b> |            |
|                  | -----             | -----        | -----        | -----        | -----              | -----        | -----      |
| Band1            | 0.00740           | 0.02526      | 0.02526      | 0.00451      | 0.02732            | 0.01610      | 0.02738    |
| Band2            | 0.01319           | 0.02881      | 0.02881      | 0.01720      | 0.02456            | -            | -          |
| Band3            | 0.04908           | 0.00849      | 0.00849      | 0.05362      | 0.00127            | -            | -          |

- Calculating ground-level downward irradiance, upward radiance, and surface reflectance in the satellite channels for each of the sites in each acquisition using the algorithm of Fraser et al. (1989) or Kneizys et al. (1988) and all the atmospheric, geometric, and radiometric data from above. The algorithm then outputs coefficients that allow conversion of any other portion of the scene to be corrected to surface reflectance. These are the satellite data conversion coefficients included in this data set.

**Processing Changes:**

None.

**Calculations:**

**Special Corrections/Adjustments:**

None.

**Calculated Variables:**

- Surface reflectance,
- Atmospheric transmittance,
- Atmospheric background radiance,
- Single scattered solar,
- Lunar radiance,
- Direct solar irradiance,
- Multiple scattered solar and thermal radiance,
- Ground-level downward irradiance, and
- Upward radiance.

## **Graphs and Plots:**

None.

## **10. Errors:**

### **Sources of Error:**

The accuracy of the satellite data conversion coefficients depends on the accuracy of the input data and the applicability of the assumptions of the atmospheric model being employed. In cases where default inputs are used, error may be greater than when measured values are used. The calibration of sunphotometers to derive optical thickness can be in error. The models vary in how multiple scattering is handled. Some of the models are not well tested under the clear (very low optical thickness) conditions sometimes observed at the FIFE study area.

### **Quality Assessment:**

#### **Data Validation by Source:**

The FIS staff has used the satellite data conversion coefficients to derive reflectances used in a number of analyses. Obvious errors have been corrected. Comparisons have been made where independent input data were available. However, there is no method of determining these coefficients, which is not dependent on an atmospheric model.

#### **Confidence Level/Accuracy Judgment:**

The spatial and temporal variability of atmospheric optical conditions affecting satellite data corrections are not well known. These coefficients are generally useful for the area of the FIFE site near the time for which they are calculated. However, correction of large-scale data (e.g., AVHRR) using default input parameters has produced suspect results.

The precision of high-resolution 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:**

No quantitative assessment was made, see the [Confidence Level/Accuracy Judgment Section](#).

Other errors mentioned in the [Sources of Error Section](#) were not assessed.

#### **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:**

None.

### **Usage Guidance:**

The satellite extract coefficients may be used to correct other portions of the imagery acquired for FIFE.

### **Any Other Relevant Information about the Study:**

None.

## **12. Application of the Data Set:**

The Satellite Image Value Conversion Coefficients Data Set contains derived coefficients that are used as inputs in algorithms that infer reflectivity of the ground from satellite radiometric data. The satellite extract coefficients may be used to correct other portions of the imagery acquired for FIFE.

## **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](mailto: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](mailto: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 Satellite Image Value Conversion Coefficients data are available on FIFE CD-ROM Volume 1. The CD-ROM file name is as follows:

```
\DATA\SAT_OBS\SAT_COEF\yyyyMULT.SEC
```

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: *yyyyMULT.sfx*, where *yyyy* are the four digits of the century and year (e.g., 1987, 1989). The filename extension (*.sfx*), identifies the data set content for the file (see the [Data Characteristics Section](#)) and is equal to *.SEC* for this data set.

## **17. References:**

### **Satellite/Instrument/Data Processing Documentation.**

Dave, J.V. 1972a. Development of programs for computing characteristics of ultraviolet radiation. Technical Report. Scalar Case. Program I. FSC-72-0009. IBM Federal Systems Division. Gaithersburg, Maryland.

Dave, J.V. 1972b. Development of programs for computing characteristics of ultraviolet radiation. Technical Report. Scalar Case. Program II. FSC-72-0011. IBM Federal Systems Division. Gaithersburg, Maryland.

Dave, J.V. 1972c. Development of programs for computing characteristics of ultraviolet radiation. Technical Report. Scalar Case. Program III. FSC-72-0012. IBM Federal Systems Division. Gaithersburg, Maryland.

Dave, J.V. 1972d. Development of programs for computing characteristics of ultraviolet radiation. Technical Report. Scalar Case. Program IV. FSC-72-0013. IBM Federal Systems Division. Gaithersburg, Maryland.

Fraser, R.S., R.A. Ferrare, Y.J. Kaufman, B.L. Markham, and S. Mattoo. 1992. Algorithm for atmospheric corrections of aircraft and satellite imagery. *Int. J. Remote Sens.* 13:541-557.

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.**

Fraser, R.S., and Y.J. Kaufman. 1985. The relative importance of aerosol scattering and absorption in remote sensing. *IEEE Transactions on Geoscience and Remote Sensing.* 23, 625-633.

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.

Price, J. C. 1983. Estimating surface temperatures from satellite thermal infrared data - a simple formulation for the atmospheric effect. *Remote Sensing Environment.* 13:353-361.

### **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:**

AVHRR Advanced Very High Resolution Radiometer. CD-ROM Compact Disk-Read Only Memory. DAAC Distributed Active Archive Center. EOSAT Earth Observation Satellite Company. EOSDIS Earth Observing System Data and Information System. FIFE First ISLSCP Field Experiment FIS FIFE Information System. HRV High Resolution Visible. IFC Intensive Field Campaign. ISLSCP International Satellite Land Surface Climatology Project. LAC Local Area Coverage. NASA National Aeronautics and Space Administration. NOAA National Oceanic and Atmospheric Administration. NRL Naval Research Laboratory. NTIS NASA Technical Information Service. ORNL Oak Ridge National Laboratory. SPOT Systeme Pour l'Observation de la Terre. TM Thematic Mapper. URL Uniform Resource Locator UTM Universal Transverse Mercator.

A general list of acronyms for the DAAC is available at [Acronyms](#).

## **20. Document Information:**

May 6, 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.

### **Document Review Date:**

September 3, 1996.

### **Document ID:**

ORNL-FIFE\_SAT\_COEF.

### **Citation:**

Cite this data set as follows:

Newcomer, J. A., and S. Goetz, 1994. Satellite Atmos[pheric]. Correction Coef[ficients]. (FIFE). Image Value Conversion Coefficients Data Set. 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/ORNLDAAAC/76](https://doi.org/10.3334/ORNLDAAAC/76). 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>