Optical Thickness Data: C-130 (FIFE)

Summary:

The data in the Sunphotometer Optical Thickness Data from C130 Aircraft data set were collected in June, July and August 1987, and in August 1989. The data was collected at selected locations within the FIFE study area.

Atmospheric optical depths derived from measurements of solar radiation by the airborne suntracking sunphotometer are available in this data set. These data are necessary for atmospheric correction of data from Earth viewing airborne and satellite sensors in the visible and near infrared regions of the electromagnetic spectrum. The data show that atmospheric optical depth changes significantly both spatially and temporally.

Variability in atmospheric optical properties and substantial differences in atmospheric optical properties during the data collection, emphasize the need to make quantitative measurements of atmospheric optical properties at the time of remote sensing data acquisition.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Optical Thickness Data: C-130 (FIFE).
(Sunphotometer Optical Thickness Data from C130 Aircraft).

Data Set Introduction:

The Sunphotometer Optical Thickness Data from C130 Aircraft Data Set contains atmospheric air mass, Rayleigh and total optical depth, atmospheric pressure, and atmospheric water data. The atmospheric optical depths available in this data set were derived from measurements of solar radiation by the airborne suntracking sunphotometer. The data in this data set were collected on nine days in June, July and August 1987, and on three days in August 1989. The data are from flight lines that targeted selected locations within the FIFE study area.

Objective/Purpose:

The goal of the research is to provide measurements of aerosol optical properties for use in quantitative corrections for atmospheric effects in remotely sensed data acquired during FIFE.

Summary of Parameters:

Atmospheric air mass, Rayleigh and total optical depth, atmospheric pressure, and atmospheric water.

Discussion:

Atmospheric optical depths derived from measurements of solar radiation by the airborne suntracking sunphotometer are available in this data set. These data are necessary for atmospheric correction of data from Earth viewing airborne and satellite sensors in the visible and near infrared regions of the electromagnetic spectrum. The data show that atmospheric optical depth changes significantly both spatially and temporally.

The data in this data set were collected on nine days in June, July and August 1987, and on three days in August 1989. The data are from flight lines that targeted selected locations within the FIFE study area.

Variability in atmospheric optical properties along some flight lines, and substantial differences in atmospheric optical properties between June 6 and October 11, 1987 (Spanner et al., 1990), underscores the need to make quantitative measurements of atmospheric optical properties at the time of remote sensing data acquisition.

Related Data Sets:

- NIPS and Reagan Sunphotometer Optical Thickness.
- Solar Transmissometer Aerosol Optical Thickness.
- Optical Thickness Calibration Reference.
- Aerosol Optical Thickness from GSFC.

FIS Data Base Table Name:

OPTICAL_THICK_C130_DATA.

2. Investigator(s):

Investigator(s) Name and Title:

Dr. Robert C. Wrigley
NASA Ames Research Center

Title of Investigation:

Optical Depth Measurements for Atmospheric Correction of Remotely Sensed Data for FIFE.

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Requested Form of Acknowledgment.

Please cite the following papers in any work or publication that uses the Sunphotometer Optical Thickness Data from the C130 Aircraft:

Spanner, M., R. Wrigley, R. Pueschel, J. Livingston, and D. Colburn. 1989. Determination of atmospheric optical properties for the First ISLSCP Field Experiment (FIFE). J. Spacecraft and Rockets, 27:373-379.

Wrigley, R.C., M.A. Spanner, R.E. Slye, R.F. Pueschel, and H.R. Aggarwal. 1992. Atmospheric correction of remotely sensed image data by a simplified model. J. Geophys. Res., 97:18797-18814.

3. Theory of Measurements:

The correction of remote sensing data acquired from satellites or aircraft 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 percent of the satellite observed radiance, but even much smaller effects would degrade the quantitative use of these data unless they are taken into account.

For atmospheric correction of satellite data, optical depths should be measured from the Earth's surface, but for aircraft-acquired data it is also necessary to measure optical depths above the aircraft so that contributions above and below the aircraft can be separated. Both can be accomplished with the airborne-suntracking sunphotometer by landing at an airport in reasonable proximity to the site of interest. For further details on the theory, see the document describing the Optical Thickness Calibration Data Set.

4. Equipment:

Sensor/Instrument Description:

The instrument consists of a solar-tracking system, detector module, temperature control system, nitrogen-purge system, mechanical drive chain, and data collection system. It automatically tracks the Sun in six narrow wavelength regions centered at 380, 450, 526, 600, 940, and 1020 nm with a 4 degrees field-of-view (Matsumoto et al., 1987)

Collection Environment:

Airborne.

Source/Platform:

C-130 Earth Resources Aircraft.

Source/Platform Mission Objectives:

The airborne tracking sunphotometer was developed for the purpose of obtaining accurate multispectral atmospheric extinction measurements at different altitudes. The solar-tracking system was designed to achieve two objectives: first, to be able to acquire the sun starting from a position several degrees away; and second, to track the sun with an accuracy of +/-2 degrees in presence of aircraft movements.

Key Variables:

Transmittance, and atmospheric pressure.

Principles of Operation:

The sensors used are Clairex photoresistors that have been matched to track each other over the operational range of sun intensities. The sensing technique uses a shadow mask that bisects each detector when the system is in balance. The design allows for very accurate tracking, yet at the same time provides a FOV and accurate tracking in a very compact package. The dome rotation is referred to as azimuth motion. The central section of the dome is free to rotate within the dome, perpendicular to the azimuth, and is referred to as elevation motion. The control system is designed to compensate for the flight characteristics of the aircraft.

Sensor/Instrument Measurement Geometry:

The six separate detectors (see the *Sensor/Instrument Description Section*) view the sun simultaneously at six independent wavelengths. The FOV of each detector is set by the entrance aperture to 4 degrees, the inside surfaces of the aperture assembly are anodized a dull black to reduce internal reflections. The 4 degrees FOV was selected to allow for +/-1 degree of tracking error without affecting the solar-radiation signal.

The system is designed to move in elevation or azimuth at 8 deg per second. The acceleration that may occur during a turn is estimated to be 1.0 rad per second squared. If the instrument should lose lock, the re-acquisition occurs very rapidly as long as the sun is in the FOV of the instrument. The tracking system responds quickly because it uses a single rate of 8 deg per second for tracking.

Manufacturer of Sensor/Instrument:

NASA Ames Research Center (ARC)
Moffett Field, CA 94035.

Calibration:

Specifications:

The detectors are temperature controlled and the amplifier gains are set with precision resistors. The resolution of the detector signals is limited by the 12 bit analog-digital converter that can resolve 1 part out of 2048 of the 0 to +10v detector signals. The instrument is designed to operate in clear skies and it is also assumed that over the period of a flight profile, there are no solar fluctuations.

Tolerance:

The six detectors located inside the detector module require absolute temperature control and are temperature controlled to 45 +/-1 degrees C by an analog temperature control system located inside the aircraft cabin. The position control electronics can withstand -55 degrees C, but the stepper motors cannot operate below -10 degrees C.

Frequency of Calibration:

The instrument is designed to retain its calibration. Nevertheless, mountain-top calibration missions are conducted as often as possible, typically once or twice a year at Mauna Loa Observatory. Calibration uses the Langley plot technique which requires clear, stable atmospheres over airmasses ranging from two to seven (i.e., airmasses measurable between sunrise and 10 AM). Three or more such data sets are required for confidence in the estimated intercepts at zero airmass.

Other Calibration Information:

The instrument can be used to look through patchy cirrus clouds but great care must be exercised in using patchy cloud data for atmospheric correction.

5. Data Acquisition Methods:

The data collection system was based on a Hewlett-Packard HP9816 computer with floppy disc and printer. This used data-collection, data-processing, and printing software developed by NASA/ARC. Besides the computer, the data collection system includes a multiplexer, a 12-bit analog to digital converter, and electronics to process the aircraft inertial navigation data. The data are sampled approximately every 2 sec and are synchronized with the aircraft data system which provides the altitude, longitude, and latitude data. The science data set includes the six detector signals, detector temperature, tracking error, sun tracker azimuth angle, sun tracker elevation angle, and UTC time (some of these parameters are not included in this FIFE data set). The computer stores the data on 3.5-inch floppy disks. The data are also printed out for real-time check and backup.

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 C130 sunphotometer data covers an area between 38.73 degrees and 39.67 degrees North latitude, and between 96.25 degrees to 97.81 degrees West longitude.

Coverage is dependent on the type of mission flown (e.g., Coordinated Mission Plan (CMP) 1, 2, or 3). Flight lines vary in altitude from 504 to 26715 feet. The flight lines are oriented perpendicular and parallel to the solar plane, ideally with 3 lines in each direction. Flight headings therefore vary with each flight line as well as with each Intensive Field Campaign (IFC) as the solar position changes.

Spatial Coverage Map:

Not available.

Spatial Resolution:

Sampling resolution is 200 m horizontally at an aircraft speed of 100 meters per sec, at an altitude of 4878 m.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

Data collection occurred during the IFCs from June 4 - October 11, 1987, and from August 4 - August 11, 1989. Data were collected on many days during this time period. However, only data for the following twelve days were prepared and submitted and are available:

```
04-JUN-87          16-AUG-87
05-JUN-87          17-AUG-87
06-JUN-87          11-OCT-87
10-JUL-87          04-AUG-89
11-JUL-87          08-AUG-89
15-AUG-87          11-AUG-89
```

Temporal Coverage Map:

Not available.

Temporal Resolution:

One spectra acquisition takes 2 seconds. Measurements were made at 2-second intervals with gaps of 2 to 20 minutes between measurement periods.

Data Characteristics:

The SQL definition for this table is found in the OT_C130.TDF file located on FIFE CD-ROM Volume 1.

Parameter/Variable Name

Parameter/Variable Description	Range	Units	Source
OBS_DATE The date that the observations were made.	min = 04-JUN-87, max = 08-AUG-89		FIS
FLIGHT_LINE The flight number line for the C-130.	# min = 4L1R1E, max = SPOT		FIS
MISSION_ID The mission ID number for the C-130 flight.	$ min = 870412, max = 8906PRE- FLIGHT		FIS
INDEX_NUM A unique index number for the record.	min = 1, max = 9408		FIS
OBS_TIME The time of the observation.	min = 0, max = 2359	[GMT]	FIS
OBS_SECONDS The seconds count for the observation. It augments the OBS_TIME column.	min = 0, max = 59		FIS

SOLAR_TIME

The time of the observation as determined by the position of the sun (absolute local time).	min = 612.21, max = 1730.32		SUNPHOTOMETER

SOLAR_ZEN_ANG The degrees off of vertical of the sun computed by 90 - SOLAR ELEVATION.	min = 16.51, max = 77.47	[degrees]	SUNPHOTOMETER

ATMOSPHERIC_AIR_MASS The atmospheric air mass. max = 4.5262	min = 1.0429,		ANEROID SENSOR

LATITUDE The latitude of the observation. max = 39.67	min = 38.73,	[degrees]	C-130

LONGITUDE The longitude of the observation. max = 97.81	min = 96.25,	[degrees]	C-130

ALTITUDE The altitude of the aircraft, as determined by the atmospheric pressure, in feet above ground level (anything under 1000 feet is suspect).	min = 504, max = 26715	[feet]	C-130

RAYLEIGH_OPTCL_THICK_380 The Rayleigh Optical Thickness at a wavelength of 380 nm.	min = .155, max = .439		FIS

RAYLEIGH_OPTCL_THICK_450 The Rayleigh Optical Thickness at a wavelength of 450 nm.	min = .077, max = .218		FIS

RAYLEIGH_OPTCL_THICK_526 The Rayleigh Optical Thickness at a wavelength of 526 nm.	min = .04 , max = .115		FIS

RAYLEIGH_OPTCL_THICK_600 The Rayleigh Optical Thickness at a wavelength of 600 nm.	min = .024, max = .067		FIS

RAYLEIGH_OPTCL_THICK_1020

The Rayleigh Optical Thickness at a wavelength of 1020 nm.	min = .003, max = .008		FIS

RAYLEIGH_OPTCL_THICK_940 The Rayleigh Optical Thickness at a wavelength of 940 nm.	min = .004, max = .011		FIS

AEROSOL_OPTCL_THICK_380 The Aerosol Optical Thickness at a wavelength of 380 nm.	min = 0, max = 2.48		FIS

AEROSOL_OPTCL_THICK_450 The Aerosol Optical Thickness at a wavelength of 450 nm.	min = .013, max = 2.614		FIS

AEROSOL_OPTCL_THICK_526 The Aerosol Optical Thickness at a wavelength of 526 nm.	min = .021, max = 2.647		FIS

AEROSOL_OPTCL_THICK_600 The Aerosol Optical Thickness at a wavelength of 600 nm.	min = 0, max = 2.487		FIS

AEROSOL_OPTCL_THICK_1020 The Aerosol Optical Thickness at a wavelength of 1020 nm.	min = 0, max = 2.646		FIS

AEROSOL_OPTCL_THICK_940 The Aerosol Optical Thickness at a wavelength of 940 nm.	min = .009, max = 3.198		FIS

ATMOSPHERIC_PRESS The atmospheric pressure during the observation.	min = 349, max = 995	[millibars]	ANEROID SENSOR

TRNSMTNC_940 The transmittance at 940 nm. max = .9999	min = .0432,		RADIOMETER

WATER_OVERBURDEN The water overburden. This calculation does not consider the aerosol contribution.	min = 0, max = 7.243	[grams] [cm^-2]	FIS

FIFE_DATA_CRTFCN_CODE * The FIFE Certification Code for	min = D,		FIS

```
the data, in the following format: max = D
CPI (Certified by PI), CPI-???
(CPI - questionable data).
```

```
LAST_REVISION_DATE
data, in the format (DD-MMM-YY).   max = 05-JUN-90
```

Footnotes:

The Flight line codes:

Example, L1R3A means line 1, run 3, site 171. Below are the codes for the rest of the sites in FIFE.

C130 SITE REF	SITE CODE
171	A
172	B
173	C
174	D
175	E
176	F
177	G
178	- NOT USED
179	- NOT USED
180	H
181	I
182	J
183	K
184-199	- NOT USED
200	L
201	M
202-239	- NOT USED
240	N
241	P
242	- NOT USED
243	R
244	S
245	T
246	U

When the flight line is specified as the following, it means : CAL data taken for calibration purposes LAND ??????? LANDSAT data taken during Landsat satellite overpass LOW low flying overpass NOAA data taken during NOAA satellite overpass NOAA9 data taken during NOAA-9 satellite overpass NOAA10 data taken during NOAA-10 satellite overpass NOAA11 data taken during NOAA-11 satellite overpass POST data taken on the ground after aircraft flight PRE data taken on the ground before aircraft flight SPIRAL data taken in flight as aircraft does spiral flight maneuver SPOT data taken during SPOT satellite overpass

$ If MISSION_ID has a PRE- or POST- attached to the mission number, the data were taken with the aircraft on the ground.

* 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	OBS_DATE	OBS_TIME	OBS_SECONDS	FLIGHT_LINE
XX31-SPS	06-JUN-87	2010	34	L1R1A
XX23-SPS	06-JUN-87	2010	36	L1R1A
XX18-SPS	06-JUN-87	2010	38	L1R1A
XX18-SPS	06-JUN-87	2010	40	L1R1A

MISSION_ID	INDEX_NUM	SOLAR_TIME	SOLAR_ZEN_ANG	ATMOSPHERIC_AIR_MASS
870416	2198	1345.500	27.9800	1.13200
870416	2199	1345.480	27.9700	1.13200
870416	2200	1345.460	27.9700	1.13200
870416	2201	1345.480	27.9900	1.13210

LATITUDE	LONGITUDE	ALTITUDE	RAYLEIGH_OPTCL_THICK_380
39.270	96.550	2066	.4150
39.270	96.570	2047	.4150
39.280	96.580	2008	.4160
39.300	96.580	1988	.4160

RAYLEIGH_OPTCL_THICK_450	RAYLEIGH_OPTCL_THICK_526	RAYLEIGH_OPTCL_THICK_600
.2060	.1090	.0630
.2060	.1090	.0640
.2060	.1090	.0640
.2060	.1090	.0640

RAYLEIGH_OPTCL_THICK_1020	RAYLEIGH_OPTCL_THICK_940	AEROSOL_OPTCL_THICK_380
.0070	.0100	.1220
.0070	.0100	.1180
.0070	.0100	.1210
.0070	.0100	.1330

AEROSOL_OPTCL_THICK_450	AEROSOL_OPTCL_THICK_526	AEROSOL_OPTCL_THICK_600
.1450	.0890	.1590
.1420	.0860	.1530
.1450	.0870	.1550
.1530	.0950	.1670

AEROSOL_OPTCL_THICK_1020	AEROSOL_OPTCL_THICK_940	ATMOSPHERIC_PRESS
.0510	.6120	940
.0470	.6130	941
.0490	.6240	942
.0600	.6410	943

TRNSMTNC_940	WATER_OVERBURDEN	FIFE_DATA_CRTFCN_CODE	LAST_REVISION_DATE
.53020	1.2550	CPI	03-MAY-88
.52680	1.2770	CPI	03-MAY-88
.52130	1.3150	CPI	03-MAY-88

.51810 1.3360 CPI 03-MAY-88

8. Data Organization:

Data Granularity:

Sampling resolution is 200 m horizontally at an aircraft speed of 100 meters per sec, at an altitude of 4878 m. Measurements were made at 2-second intervals with gaps of 2 to 20 minutes between measurement periods.

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:

Briefly, the data derivation sequence begins with the voltages from each of the six photodetectors in the sunphotometer (Spanner et al., 1990). It was assumed that the attenuation of solar radiation was adequately described by the Bouguer-Lambert-Beer extinction law:

V = (R'/ R)^2 V_o exp(-mtau) (1)

where:

Caret (^) = superscripts
Underscore (_) = subscripts
V = detector voltage
V_o = zero air mass voltage intercept for the mean Earth-Sun separation R'
VR = separation at the time of observation
m = air mass between the instrument and the Sun
t = total optical depth above the sun photometer

Detector voltages were screened to remove low values due to attenuation by clouds, loss of Sun acquisition during steeply banked turns, or obstruction of the Sun by the C-130 tail section. Air mass was calculated from solar ephemeris data. Total optical spectral optical depths were calculated using Equation (1). The total optical depths included attenuation due to molecular (Rayleigh) scattering, aerosol extinction, and gaseous absorption:

tau_t = tau_r + tau_a + tau_O3 + tau_NO2 + tau_H2O (2)

Net optical depths were calculated by subtracting reasonable estimates of Rayleigh scattering contributions; note that this subtraction leaves the ozone, nitrous oxide, and water vapor contributions untouched. Header files for each data set were provided to FIFE staff that included best estimates for these contributions, but they were not otherwise accounted for in the optical data sent to FIFE staff.

Data Processing Sequence:

Processing Steps:

A detailed description of data processing steps and manipulations is given in Spanner et al. (1990) in the Methods Section (pages 375-376).

Processing Changes:

None.

Calculations:

Special Corrections/Adjustments:

None.

Calculated Variables:

- Attenuation of solar radiation.
- Air mass.
- Total optical spectral optical depths.
- Net optical depths.

Graphs and Plots:

None.

10. Errors:

Sources of Error:

The primary source of error for derivation of optical depths from airborne tracking Sun photometer data is the slowly changing set of zero air mass voltage intercepts. The instrument is temperature stabilized and that removes the low order voltage drifts, but the filter/detector packages degrade slowly in time due to a variety of factors. It must be assumed the degradation is linear in time between mountain-top calibrations.

Quality Assessment:

Data Validation by Source:

A number of side-by-side measurements of total spectral optical depths were made with sunphotometers from other investigators to intercompare the instruments. Bruegge et al. (1992) reported the optical depths measured in 1987 agreed within +/-0.05 units of optical depth and that those measured in 1989 agreed within +/-0.02.

Confidence Level/Accuracy Judgment:

Not available.

Measurement Error for Parameters:

Sensitivity studies and intercomparisons used to infer error. See Bruegge et al. (1992).

No quantitative assessment was made for other errors referred to in the *Sources of Error Section*.

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).
- 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:

discrepancies or errors in the data have been reported:

1. Aerosol optical thickness for all wavelengths has unexpectedly high values (greater than 1.5) on July 11, 1987 between 1912 and 1913 hours for flight line L5R1G and a mission id of 870517. Use these data with caution.
2. The WATER_OVERBURDEN field has spikes in the data (values greater than 6.0) on the following days for the MISSION_IDs and FLIGHT_LINEs listed below.

Date	Mission_ID	Flight_Line
10-JUL-87	870514	PRE
11-JUL-87	870517	SPIRAL
15-AUG-87	870615	POST
16-AUG-87	870615	POST
4-AUG-89	890606	POST
4-AUG-89	890606	PRE
4-AUG-89	890606	SPIRAL
11-AUG-89	890617	PRE
11-AUG-89	890617	SPIRAL

3. The filter/detector combination for the 380 nm channel is known to degrade the most quickly and might be the most susceptible to errors in the interpolation of zero air mass intercepts with time. The 600 nm channel sometimes exhibited anomalous rapid changes in optical depth that were not correlated with other channels and appeared to have no physical meaning. Calibration of the water vapor channel (940 nm) is very difficult; comparison with other results is required.

Usage Guidance:

The reported aerosol optical depths should be adjusted for optical depths due to absorbing gases: ozone, nitrous oxide, and water vapor. For ozone, we (Wrigley et al., 1992) used a climatological model by van Heuklon (1979), but satellite ozone measurements should be preferred. For nitrous oxide, we used values from Noxon (1979), but since the optical depth corrections were very small, little error should ensue from errors in nitrous oxide concentration. We ignored water vapor optical depths since the spectral bands in question were specifically chosen to avoid water vapor absorption.

Any Other Relevant Information about the Study:

None.

12. Application of the Data Set:

The aerosol optical property measurements contained in this data set can be used in quantitative corrections for atmospheric effects in remotely sensed data acquired during 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
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Data Center Identification:

ORNL Distributed Active Archive Center
Oak Ridge National Laboratory
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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 Sunphotometer Optical Thickness Data from C130 Aircraft are available on FIFE CD-ROM Volume 1. The CD-ROM filename is as follows:

\DATA\OPTICAL\OT_C130\yyddd\ydddhhmm.OTC

Where *yy* is the last two digits of the year (e.g., 87 = 1987) and *ddd* is the day of the year, (e.g., 061 = sixty-first day in the year). Note: capital letters indicate fixed values that appear on the CD-ROM exactly as shown here, lowercase indicates characters (values) that change for each path and file.

The format used for the filenames is: *ydddhhmm.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, *hh* is the GMT hour and *mm* are the GMT minutes. The filename extension (.*sfx*), identifies the data set content for the file (see the *Data Characteristics Section*) and is equal to .OTC for this data set.

17. References:

Satellite/Instrument/Data Processing Documentation.

Matsumoto, T., P. Russell, C. Mina, W. Van Ark, and V. Banta. 1987. Airborne tracking sunphotometer. J. Atmos. Oceanic Technol. 4:336-339.

Journal Articles and Study Reports.

Angstrom, T. 1929. On the atmospheric transmission of sun radiation and on dust in the air. Geogr. Ann. 11:156-166.

Bruegge, C.J., R.N. Halthore, B.L. Markham, M. Spanner and R. Wrigley.1992. Aerosol optical depth retrievals over the Konza Prairie. J. Geophys. Res. 97:18,743-18,758.

Bruegge, C.J., J.E. Conel, R.O. Green, J.S. Margolis, G. Toon and R.G. Holm. 1992. Water-vapor column abundance retrievals. J. Geophy. Res. 97:18759-18768.

Frohlich, C., and G. Shaw. 1980. New determination of Rayleigh scattering in the terrestrial atmosphere. Appl. Opt. 19:1773-1775.

King, M., D. Bryne, B. Herman, and J. Reagan. 1978. Aerosol size distributions obtained by inversion of spectral optical depth measurements. J. Atmos. Sci. 35:2153-2167.

Noxon, J. 1979. Stratospheric NO2, 2 Global behavior, J. Geophys. Res.84, 5067-5076.

Russell, P., T. Matsumoto, V. Banta, J. Livingston, C. Mina, D. Colburn, and R. Pueschel. 1986. Measurements with an airborne, autotracking, external-head sunphotometer. Proc. 6th. Conf. on Atmospheric Radiation. Williamsburg, VA. May 13-16. Am. Meteol. Soc. 4p.

Sellers P.J., F.G. Hall, D.E. Strebel, E.T. Kanemasu, R.D. Kelly, B.L. Blad, B.J. Markham, and J.R. Wang. 1990. Experiment design and operations. AMS Symposium on the First ISLSCP Field Experiment (FIFE). Anaheim, CA. February 7-9.

Spanner, M., R. Wrigley, R. Pueschel, J. Livingston, and D. Colburn. 1990. Determination of atmospheric optical properties for the First ISLSCP Field Experiment (FIFE). J. Spacecraft and Rockets. 27:373-379.

Van Heuklon, T. 1979. Estimating atmospheric ozone for solar radiation models. Solar Energy, 22:63-68.

Wrigley, R.C., M.A. Spanner, R.E. Slye, R.F. Pueschel, and H.R. Aggarwal.1992. Atmospheric correction of remotely sensed image data by a simplified model. J. Geophys. Res. 97:18797-18814.

Young, A. 1980. Revised polarization corrections for atmospheric extinction. Appl. Opt. 20:3427-2428.

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:

ARC Ames Research Center 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 FOV Field of View ISLSCP International Satellite Land Surface Climatology Project ORNL Oak Ridge National Laboratory 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).

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.

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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).

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