Soil Thermal Conductivity Data (FIFE)

Summary:

The purpose of the 1989 FIFE soil properties investigation was to obtain a description of the thermal properties of the soils within the FIFE study area. Soil thermal conductivity measurements describe the soil properties which govern the flow of heat through the soil. The thermal conductivity is defined as the quantity of heat that flows through a unit area in a unit time under a unit temperature gradient.

These measurements were made using a hot wire probe in situ at two depths at twenty six FIFE sites during October 1987. The measurements were taken using a long electrically heated wire enclosed in a cylindrical probe . The probe is placed in the soil, the wire is heated by running a current through it, and the temperature rise is measured with a thermocouple placed next to the wire. A plot of temperature versus the log of time can be used to derive the thermal conductivity. The results may require a correction factor to account for the dimensions of the probe.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

Soil Thermal Conductivity Data (FIFE).

Data Set Introduction:

The Soil Thermal Conductivity Data Set contains thermal conductivity and soil moisture data collected using a hot wire probe at two depths at twenty six FIFE sites during October 1987.

Objective/Purpose:

The purpose of the 1989 FIFE soil properties investigation was to obtain a description of the thermal properties of the soils within the FIFE study area.

Summary of Parameters:

Thermal conductivity and soil moisture.

Discussion:

Soil thermal conductivity measurements describe the soil properties which govern the flow of heat through the soil. The thermal conductivity is defined as the quantity of heat that flows through a unit area in a unit time under a unit temperature gradient. These measurements were made using a hot wire probe in situ at two depths at twenty six FIFE sites during October 1987.

Related Data Sets:

- Soil Moisture Release.
- Soil Water Properties.
- Soil Hydraulic Conductivity.
- Gravimetric Soil Moisture.
- Soil Properties Reference Information.

FIS Data Base Table Name:

SOIL_THERMAL_CONDUCT_DATA.

2. Investigator(s):

Investigator(s) Name and Title:

Dr. Edward T. Kanemasu, Leader
Kansas State University

Present Address:
University of Georgia

Title of Investigation:

1989 FIFE Staff Soil Properties Measurements.

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Requested Form of Acknowledgment.

The Soil Thermal Conductivity data were collected and provided by the Evapotranspiration Laboratory at Kansas State University.

3. Theory of Measurements:

The measurements were made using a hot wire probe where a long electrically heated wire is enclosed in a cylindrical probe. The probe is placed in the soil, the wire is heated by running a current through it, and the temperature rise is measured with a thermocouple placed next to the wire. For a short distance from the wire, the rise in temperature is given by:

$$T - To = (q / (4 * PI * c) * (a + \ln(t))$$

Where **T** is the measured temperature, **To** is the initial temperature, **q** is the heat generated per unit time and unit length of the wire, **c** is the thermal conductivity, **a** is a constant, and **t** is time. A plot of temperature versus the log of time can be used to derive the thermal conductivity. The results may require a correction factor to account for the dimensions of the probe.

4. Equipment:

Sensor/Instrument Description:

A cylindrical probe with a long electrically heated wire is placed in contact with the soil.

Collection Environment:

Ground.

Source/Platform:

These are ground based measurements.

Source/Platform Mission Objectives:

Determination of soil thermal conductivity.

Key Variables:

- Soil thermal conductivity [Watts][m^-2][C^-1].
- Gravimetric soil moisture [percent].

Principles of Operation:

Methods of measuring soil thermal conductivity using transient heat flows are considered to be more accurate than steady state methods. Transient methods minimize effects of water movement due to temperature gradients and do not require the long wait for the temperature gradients to stabilize.

Sensor/Instrument Measurement Geometry:

The probe was placed in contact with the soil at two depths, 5 and 10 cm at each site.

Manufacturer of Sensor/Instrument:

Not available at this revision.

Calibration:

Specifications:

Not available at this revision.

Tolerance:

Not available at this revision.

Frequency of Calibration:

Not available at this revision.

Other Calibration Information:

None.

5. Data Acquisition Methods:

The probe was placed in contact with the soil at two depths, 5 and 10 cm at each site. Also soil samples were collected from 0 to 5 cm and 5 to 10 cm depths and weighted, dried, and weighted again to determine the gravimetric soil moisture at the location and time of the thermal conductivity measurements.

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 upper left corner of the area has UTM coordinates of 4,334,000 Northing and 705,000 Easting in UTM zone 14.

Spatial Coverage:

The Soil Thermal Conductivity data was collected at 26 sites scattered over the entire FIFE study area. The station id's and sitegrid id's for the sites are listed below:

STATION_ID	SITEGRID	STATION_ID	SITEGRID
1	2731-STC	24	6912-STC
2	1916-STC	25	4168-STC
3	2428-STC	26	8739-STC
4	2731-STC	28	6934-STC
5	2123-STC	29	0847-STC
6	2132-STC	30	4268-STC
7	3221-STC	31	2139-STC
8	3129-STC	34	3479-STC
10	3414-STC	36	2655-STC
12	2915-STC	38	1478-STC
14	2516-STC	40	1246-STC
20	6340-STC	42	1445-STC

22 4609-STC 44 2043-STC

Spatial Coverage Map:

Not available.

Spatial Resolution:

These data are point samples. Each site has samples collected at 5 and 10 cm.

Projection:

Not available.

Grid Description:

Not available.

Temporal Characteristics:

Temporal Coverage:

These data were collected on a single day, October 18, 1987.

Temporal Coverage Map:

Not available.

Temporal Resolution:

The observations were collected once, on a single day.

Data Characteristics:

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

Parameter/Variable Name

Parameter/Variable Description **Range** **Units** **Source**

SITEGRID_ID This is a FIS grid location code. Site grid codes (SSEE-III) give the south (SS) and the east (EE) cell number in a 100 x 100 array of 200 m square cells. The last 3 characters (III) are an instrument identifier.		
STATION_ID The station ID designating the location of the observations.		
OBS_DATE The date of the observations, in the format (DD-MMM-YY).		
DEPTH The depth of the measurements.		[cm]
SOIL_MOISTURE_GRAVMTRC The soil moisture at this depth determined gravimetrically.		[percent]
THERMAL_CONDCTVTY The thermal conductivity of the soil at this depth, determined by a hot wire probe.		[Watts] [meter^-1] [degrees C]
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:

Decode the FIFE_DATA_CRTFCN_CODE field as follows:

The primary certification codes are: EXM Example or Test data (not for release). PRE Preliminary (unchecked, use at your own risk). CPI Checked by Principal Investigator (reviewed for quality). CGR Checked by a group and reconciled (data comparisons and cross-checks).

The certification code modifiers are: PRE-NFP Preliminary - Not for publication, at the request of investigator. CPI-MRG PAMS data that are "merged" from two separate receiving stations to eliminate transmission errors. CPI-??? Investigator thinks data item may be questionable.

Sample Data Record:

SITEGRID_ID	STATION_ID	OBS_DATE	DEPTH	SOIL_MOISTURE_GRAVMTRC
1916-STC	2	18-OCT-87	5	12.20
1916-STC	2	18-OCT-87	10	13.80
2731-STC	1	18-OCT-87	5	-9.90
2731-STC	1	18-OCT-87	10	-9.90

THERMAL_CONDCTVTY	FIFE_DATA_CRTFCN_CODE	LAST_REVISION_DATE
.18	CPI	05-NOV-93
.58	CPI	05-NOV-93
-9.90	CPI	05-NOV-93
-9.90	CPI	05-NOV-93

8. Data Organization:

Data Granularity:

These data are point samples. Each site has samples collected at 5 and 10 cm on October 18, 1987.

A general description of data granularity as it applies to the IMS appears in the EOSDIS Glossary.

Data Format:

The CD-ROM file format consists of numerical and character fields of varying length separated by commas. The character fields are enclosed with a single apostrophe. There are no spaces between the fields. Each file begins with five header records. Header records contain the following information: Record 1 Name of this file, its table name, number of records in this file, path and name of the document that describes the data in this file, and name of principal investigator for these data. Record 2 Path and filename of the previous data set, and path and filename of the next data set. (Path and filenames for files that contain another set of data taken at the same site on the same day.) Record 3 Path and filename of the previous site, and path and filename of the next site. (Path and filenames for files of the same data set taken on the same day for the previous and next sites (sequentially numbered by SITEGRID_ID)). Record 4 Path and filename of the previous date, and path and filename of the next date. (Path and filenames for files of the same data set taken at the same site for the previous and next date.) Record 5 Column names for the data within the file, delimited by commas. Record 6 Data records begin.

Each field represents one of the attributes listed in the chart in the *Data Characteristics Section* and described in detail in the TDF file. These fields are in the same order as in the chart.

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

The measurements were made using a hot wire probe where a long electrically heated wire is enclosed in a cylindrical probe. The probe is placed in the soil, the wire is heated by running a current through it, and the temperature rise is measured with a thermocouple placed next to the wire. For a short distance from the wire, the rise in temperature is given by:

T - To = (q / (4 * PI * c) * (a + ln(t))

Where **T** is the measured temperature, **To** is the initial temperature, **q** is the heat generated per unit time and unit length of the wire, **c** is the thermal conductivity, **PI** is 3.14159, **a** is a constant, and **t** is time. A plot of temperature versus the log of time can be used to derive the thermal conductivity. The conductivity **c** is calculated by comparing the measured slope **S** to the theoretical slope **q / (4 * PI * c)**. Using common logarithms of the time data gives the measured slope as:

S = 2.303 * q / (4 * PI * c)

The heat produced **Q** is obtained from the current (**I**) and resistance (R) measurements, substituting **R * I^2** for **q** gives the following:

c = (18.34 * R * I^2) / S

Data Processing Sequence:

Processing Steps:

Not available at this revision.

Processing Changes:

None.

Calculations:

Special Corrections/Adjustments:

A correction factor may be necessary to account for the dimensions of the probe. It is not known if a factor was used on these data.

Calculated Variables:

- Rise in temperature,
- Conductivity, and
- Heat produced.

Graphs and Plots:

None.

10. Errors:

Sources of Error:

This method is affected by temperature induced water movement in the soil, however this effect is believed to be small because the heat source is transient and short lived, not allowing time for errors to accumulate due to water movement.

Quality Assessment:

Data Validation by Source:

Not available at this revision.

Confidence Level/Accuracy Judgment:

Not available at this revision.

Measurement Error for Parameters:

Not available at this revision.

Additional Quality Assessments:

Not available at this revision.

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:

Not available at this revision.

Usage Guidance:

This data set can be used in conjunction with the soil moisture release and soil hydraulic conductivity data to describe heat and moisture transfer for the soil types in FIFE. The Soil Properties Reference Information Data Set also has further descriptions of soil properties for these soils.

Any Other Relevant Information about the Study:

Not available at this revision.

12. Application of the Data Set:

This data set can be used in conjunction with the soil moisture release and soil hydraulic conductivity data to describe heat and moisture transfer for the soil types in 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

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 Soil Thermal Conductivity data are available on the FIFE CD-ROM Volume 1. The CD-ROM filename is as follows:

DATA\SOILPROP\SOILTHER\1987MULT.STC

17. References:

Satellite/Instrument/Data Processing Documentation.

Not available at this revision.

Journal Articles and Study Reports.

Campbell, G.S. 1985. Soil Physics with BASIC. Transport Models for Soil-Plant Systems pp 150. Elsevier, New York.

Jackson, R.D., S.A. Taylor. 1986. Thermal Conductivity and Diffusivity. In: Methods of Soil Analysis Part 1 Physical and Mineralogical Methods. Agronomy Monograph no. 9 (2nd Edition) pp 945-956. Amer. Soc. Agron. Madison.

DeVries, D.A. 1952. A nonstationary method for determining thermal conductivity of soil in situ. Soil Sci. 73:83-89.

DeVries, D.A. and Peck, A.J. 1958. On the cylindrical probe method of measuring thermal conductivity with special reference to soils: I. Extension of theory and discussion of probe characteristics. Aust. J. Phy. 11:255-271.

DeVries, D.A. and Peck, A.J. 1958. On the cylindrical probe method of measuring thermal conductivity with special reference to soils: II. Analysis of moisture effects. Aust. J. Phys. 11:409-423

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:

CD-ROM Compact Disk-Read Only Memory DAAC Distributed Active Archive Center EOS Earth Observation Center EOSDIS EOS Data and Information System FIFE First ISLSCP Field Experiment FIS FIFE Information System ISLSCP International Satellite Land Surface Climatology Project KSU Kansas State University ORNL Oak Ridge National Laboratory TDF Table Definition File 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 15, 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:

June 28, 1996.

Document ID:

ORNL-FIFE_SOILTHER.

Citation:

Cite this data set as follows:

Kanemasu, E. T. 1994. Soil Thermal Conductivity Data (FIFE). Data set. Available on-line [http://www.daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/116. 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).

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