SMEX02 Watershed Soil Moisture Data, Walnut Creek, Iowa, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

Jackson, T. and M. Cosh. 2003. *SMEX02 Watershed Soil Moisture Data, Walnut Creek, Iowa, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/OAO4SU0XZLGR. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/NSIDC-0143

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

1.1 Format

Data consist of ASCII tab-delimited text files.

1.2 File and Directory Structure

Data files are in subdirectories according to the data type and collection method. The subdirectories are described in the following table.

Subdirectory Name	Parameter in Data Files
bulk_density	Bulk density, manually collected soil samples; raw and summary data
gravimetric	Gravimetric soil moisture, manually collected soil samples
soil_and_surface_temp	Surface and subsurface soil temperature, measured with infrared pyrometers; raw data
soil_and_surface_temp_avg	Surface and subsurface soil temperature, measured with infrared pyrometers; summary data
theta_probe	Surface volumetric soil moisture measured with impedance probes (ThetaProbes); raw data
theta_probe_avg	Surface volumetric soil moisture measured with impedance probes (ThetaProbes); summary data

1.3 File Naming Convention

All data files have the file name extension ".txt". File names may be uppercase or mixed upper- and lowercase. Most data file names contain the letters "WC" to designate the Walnut Creek watershed site. When applicable for a given parameter, raw data file names contain the letters "raw" and summary data file names contain the letters "sum". Bulk density file names contain the letters "BD". Gravimetric soil moisture data file names contain the letters "GSM" (file SOILCAN.txt is the soil can weight file). Temperature data file names contain the letters "TEMP". Volumetric soil moisture (ThetaProbe) files contain the letters "TP".

1.4 Spatial Coverage

Southernmost Latitude: 41.7° N
Northernmost Latitude: 42.7° N
Westernmost Longitude: 93.8° W
Easternmost Longitude: 93.2° W

1.5 Temporal Coverage

Data were collected daily from 23 June 2002 to 12 July 2002.

1.6 Parameter or Variable

1.6.1 Parameter Description

Parameters in this data set include bulk density, gravimetric and volumetric soil moisture, and surface and subsurface soil temperature. The following table describes the units of measurement and sources of each parameter.

Parameter	Unit of Measurement	Source/Sensor
Bulk density	g/cm^3	Manual soil collection
Gravimetric soil moisture	grams of water per grams of dry soil	Manual soil collection
Surface and subsurface soil temperature	°C	Infrared pyrometers and temperature probes
Volumetric soil moisture	water fraction volume (m^3/m^3)	Impedance probes (ThetaProbes)

The tab-delimited ASCII text files contain data in row and column format. In each file, header rows indicate the contents of each column, and the headers are followed by data rows. The following sections describe the contents of the various data files. For each file, the column headings are listed, exactly as they appear in the data files, along with a brief description of each columns' contents. Field coordinates are given in the WGS84 Datum. Any suspect or missing data in the files are flagged with a "null" value such as -99 or -999.

Bulk Density

The raw bulk density data file, "RawDataSMEX02BD.txt", contains the following information.

Column Heading	Description
Site ID	Site name
Date (M/D/Y)	Month/day/year
Row Spacing	Location in crop row: "In", "Between", or "none", indicating in a row, between rows, or no rows (such as broadcast soybeans)
Site Loca	Specific sampling location in site, either a, b, c, or d
Veg Crop	Type of crop
Start Volume	Starting volume in ml

Column Heading	Description
Final Volume	Final volume in ml
Total Volume	Total volume in ml
Bag Tare Wt	Weight of empty sample bag in g
Wet Weight	Weight of wet soil in g
Dry Weight	Weight of dry soil in g
% H2O	Gravimetric soil moisture
BD g/cm ^{3}	Bulk density (g/cm^3)
(no heading given)	Notes, if any

The summary file, "SumDataSMEX02BD.txt", contains the following information (the means of all samples at each site).

Column Heading	Description
Site ID	Site name
Date (m/d/y)	Month/day/year
Row Spacing	Location in crop row: "IN", "BE", or "AL", indicating in a row, between rows, or all the same
Veg Crop	Type of crop
BD g/cm ^{3}	Bulk density (g/cm^3)
(no heading given)	Notes, if any

Gravimetric Soil Moisture

The raw gravimetric soil moisture data file, "WC_GSM_RAW.txt", contains the following information.

Column Heading	Description
Date	Sample date as month/day/year
DOY	Numerical day of the year
SiteID	Site identifier (WCnn, where nn is site number)
Sample	Measurement location number in each site
Lat	Latitude of the site in decimal degrees
Lon	Longitude of the site in decimal degrees
UTM Easting in m	Universal Transverse Mercator (UTM) Easting in meters
UTM Northing in m	UTM Northing in meters
CanID	ID that distinguishes between soil cans of different weights
Depth	Code indicating depth; 0 = 0-1 cm, 1 = 1-6 cm
WetWgt in g	Initial wet soil weight in grams

Column Heading	Description
DryWgt in g	Dry soil weight in grams
GSM in g/g	Gravimetric soil moisture in grams of water per grams of soil
Notes	Notes about the data, if any

The summary gravimetric soil moisture data file, "WC_GSM_SUM.txt", contains the following information.

Column Heading	Description
Date	Sample date as month/day/year
DOY	Numerical day of the year
SiteID	Site identifier (WCnn, where nn is site number)
Lat Centroid	Latitude of the site centroid in decimal degrees
Lon Centroid	Longitude of the site centroid in decimal degrees
UTM Easting in m Centroid	UTM Easting in meters of site centroid
UTM Northing in m Centroid	UTM Northing in meters of site centroid
#samples	Number of samples per site per day
start time (CDT)	Start time of sampling in local time
stop time (CDT)	Stop time of sampling in local time
average (0-1cm) in grams	Mean GSM of 0-1 cm depth
stdev (0-1cm) in grams	Standard deviation of GSM of 0-1 cm depth
average (1-6cm) in grams	Mean GSM of 1-6 cm depth
stdev (1-6cm) in grams	Standard deviation of GSM of 1-6 cm depth
average (0-6 cm) in grams	Mean GSM of 0-6 cm depth
stdev (0-6cm) in grams	Standard deviation of GSM of 0-6 cm depth
Notes	Notes about the data, if any

The "SOILCAN.txt" file contains can number and the weight, in grams, of the various soil cans used for sample collection. When soil can weights are not available, the average weight of all the cans should be used, because they are all of the same type.

Temperature

The raw temperature file, "WC_TEMP_RAW.txt", contains the following information.

Column Heading	Description
Date	Date in month/day/year format
DOY	Numerical day of the year

Column Heading	Description
Site ID	Site identifier (WCnn, where nn is site number)
Sample	Measurement location code in each site
latitude	Latitude in decimal degrees
longtide	Longitude in decimal degrees
Easting	UTM Easting in meters (Zone 15)
Northing	UTM Northing in meters (Zone 15)
LST	Land surface temperature in °C
1 cm	Soil temperature at 1 cm depth in °C
5 cm	Soil temperature at 5 cm depth in °C
10 cm	Soil temperature at 10 cm depth in °C

The summary temperature file, "WC_TEMP_SUM.txt", contains the means and standard deviation by field (site) and day, including the following information.

Column Heading	Description
Date	Date in month/day/year format
DOY	Numerical day of the year
Site ID	Site identifier (WCnn, where nn is site number)
latitude	Latitude in decimal degrees
longitude	Longitude in decimal degrees
Easting	UTM Easting of centroid of sampling sites in meters
northing	UTM Northing of centroid of sampling sites in meters
number points	Number of samples per site per day
start tme	Start time of sampling in local time
stop time	Stop time of sampling in local time
average LST	Mean land surface temperature
stdev LST	Standard deviation of land surface temperature
average 1 cm	Mean soil temperature at 1 cm depth
stdev 1 cm	Standard deviation of soil temperature at 1 cm depth
average 5 cm	Mean soil temperature at 5 cm depth
stdev 5 cm	Standard deviation of soil temperature at 5 cm depth
average 10 cm	Mean soil temperature at 10 cm depth
stdev 10 cm	Standard deviation of soil temperature at 10 cm depth

Volumetric Soil Moisture (ThetaProbe)

The raw volumetric soil moisture (ThetaProbe) data file, "WC_TP_RAW.txt", contains the following information.

Column Heading	Description
Date	Date as month/day/year
DOY	Numerical day of the year
SiteID	Site identifier (WCnn, where nn is site number)
SampleNo	Measurement location number in each site
Latitude	Latitude in decimal degrees
Longitude	Longitude in decimal degrees
Easting	UTM Easting in meters (Zone 15)
Northing	UTM Northing in meters (Zone 15)
Row	Location in tilled row: 0 = in row; for example, in line with planted corn or soybeans 0.5 = midpoint between two rows of planted crops 0.25 = midway between the 0 and 0.5 locations
V	ThetaProbe voltage output in volts
VSM_gc	Volumetric soil moisture content from generalized calibration of voltage data
VSM_ssc	Volumetric soil moisture content from specific calibration of voltage data

The summary volumetric soil moisture (ThetaProbe) data file, "WC_TP_SUM.txt", contains the following information.

Column Heading	Description
Date	Date as month/day/year
DOY	Numerical day of the year
SiteID	Site identifier (WCnn, where nn is site number)
Latitude	Latitude in decimal degrees
Longitude	Longitude in decimal degrees
Easting	UTM Easting in meters (Zone 15)
Northing	UTM Northing in meters (Zone 15)
#ofsamples	Number of samples taken at site
V	Average ThetaProbe voltage output in volts
Stdev	Standard deviation of ThetaProbe voltage output in volts
VSM_gc	Volumetric soil moisture content from generalized calibration of voltage data

Column Heading	Description
Stdev	Standard deviation of VSM_gc
VSM_ssc	Volumetric soil moisture content from specific calibration of voltage data
Stdev	Standard deviation of VSM_ssc

1.6.2 Sample Data Record

The following sample is from the raw gravimetric soil moisture data file "WC_GSM_Raw.txt". Not all columns are shown.

Date	DOY	...	Sample	...	CanID	Depth	WetWgt in g	DryWgt in g	GSM in g/g
6/25/2002	176	...	2	...	129	0	83.2	79.1	0.107
6/25/2002	176	...	2	...	130	1	137.2	124.8	0.147
6/25/2002	176	...	6	...	131	0	84.3	81	0.083
6/25/2002	176	...	6	...	132	1	136.6	118.8	0.227
6/25/2002	176	...	9	...	133	0	79.5	75.8	0.106
6/25/2002	176	...	9	...	134	1	148	133.3	0.159
6/25/2002	176	...	13	...	135	0	63.2	61	0.109
6/25/2002	176	...	13	...	136	1	170.6	144.6	0.252

The following sample is from the average temperature data file "WC_TEMP_SUM.txt." Not all columns are shown.

Date	...	Site ID	...	number points	...	average LST	...	stdev 1 cm	...	average 10 cm	stdev 10 cm
6/25/2002	...	WC01	...	4	...	37.25	...	3.153	...	25.9	1.134
6/25/2002	...	WC03	...	5	...	38	...	3.564	...	27.9	1.342
6/25/2002	...	WC04	...	4	...	44.5	...	4.125	...	26.225	1.664
6/25/2002	...	WC05	...	4	...	31.5	...	1.746	...	24	1.92
6/25/2002	...	WC06	...	5	...	30	...	3.009	...	25.12	0.638
6/25/2002	...	WC08	...	4	...	32.25	...	1.352	...	23.875	0.206

2 SOFTWARE AND TOOLS

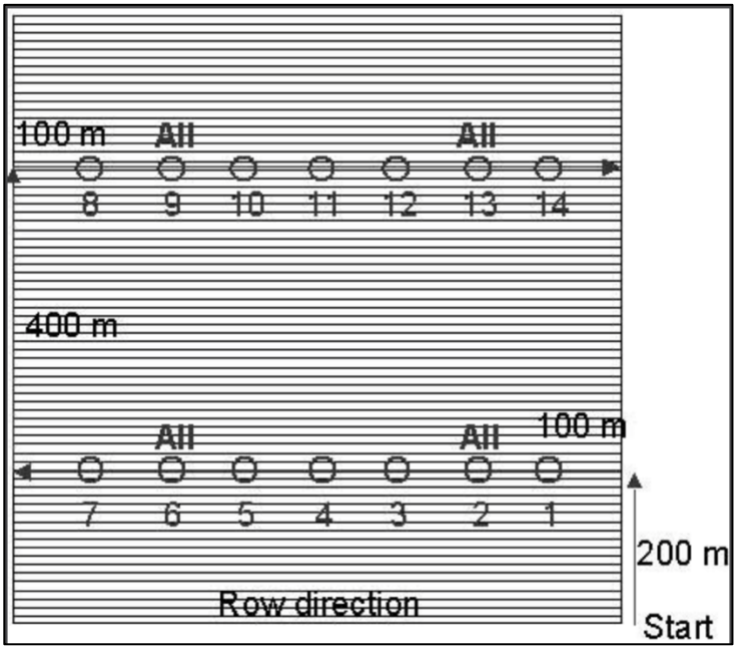
No special tools are required to view these data

3 DATA ACQUISITION AND PROCESSING

3.1 Data Acquisition Methods

3.1.1 Section Sampling

Sampling was performed on sites approximately one quarter section (0.8 km by 0.8 km) in size. As shown in the following illustration, 14 points were sampled in a field for a variety of variables. The site sampling generally took place each morning between approximately 8:00 a.m. and 11:30 a.m., local time. Some samples (such as gravimetric soil moisture and temperature), were taken at only four points in a site, marked "All" in the illustration. If the sampled field had a flux tower, additional sampling was done at the base of each tower.



3.1.2 Section Sampling Layout

The sampling site numbers are included in the gravimetric soil moisture raw data file ("WC_GSM_Raw.txt") and both (ThetaProbe) volumetric soil moisture data files ("WC_TP_RAW.txt" and "WC_TP_SUM.txt").

3.1.3 Bulk Density Sampling

Bulk density sampling was conducted at all sites. In general, four samples per site were taken. Efforts were made to co-locate the bulk density samples with the gravimetric soil moisture sampling points. In cases where these points could not be easily identified, approximations of location were

made. After selecting a location, vegetation was removed and a volume of surface soil was extracted to a depth of 5 cm. Where row direction could be determined, two samples were taken directly in the row of plants (row spacing noted as "In" in the raw data file) and two samples were taken halfway between the plant rows (row spacing noted as "Between"). In the case of broadcast soybeans, "none" is noted as the row spacing.

3.1.4 Temperature Sampling

Surface and subsurface soil temperature sampling was conducted at the four points selected for gravimetric soil moisture (GSM) sampling in each section (marked "All" in the Section Sampling Layout illustration). The surface temperature was sampled using handheld infrared thermometers, with one averaged surface thermal infrared temperature made per point. Soil temperature was obtained using a digital temperature probe inserted to depths of 1 cm, 5 cm and 10 cm.

3.1.5 Gravimetric Soil Moisture Sampling

Gravimetric soil moisture samples were taken at only four points, marked "All" in the Section Sampling Layout illustration. Researchers took 6 cm deep samples at each point using a scoop tool. Each sample was was then cut into a 0 cm to 1 cm depth section and a 1 cm to 6 cm depth section.

3.1.6 Volumetric Soil Moisture (Impedance ThetaProbe) Sampling

Investigators used manually inserted impedance probes (ThetaProbes) and a handheld reader to measure surface volumetric soil moisture. The probe was inserted vertically into the soil (0-

3.2 Derivation Techniques and Algorithms

3.2.1 Processing Steps

3.2.1.1 Bulk Density Processing

Using the volume of soil extracted and the dry weight of the soil extracted, the bulk density was computed using the following steps:

- Compute volume of soil extracted: volume total = volume end - volume start
- Compute dry soil mass extracted: sample dry weight - bag tare weight
- Compute bulk density: dry soil mass extracted / soil volume extracted

It is also possible to compute the soil moisture of the sample used for bulk density using the following formula:

Gravimetric soil moisture = (wet weight - dry weight) / dry weight

When summarizing the data, if the in-plant row measurements (noted as "IN") were greater than 0.10 different than the halfway-between-plant row measurements (noted as "BE"), both values are given for the field. If this difference was less than 0.10, it is assumed that there was no difference between the bulk density samples, and a single value (noted as "AL") is reported for all of the field.

3.2.1.2 Gravimetric Soil Moisture Processing

Researchers used a balance to weigh the wet soil obtained in the field, heated the soil in an oven to dry it, then weighed the dry soil. The soil moisture of the sample can be calculated using the following formula:

Gravimetric soil moisture = (wet weight - dry weight) / dry weight

Investigators used soil bulk density to convert the gravimetric samples to volumetric soil moisture using a volume extraction technique. Four samples per site were taken. Where they could determine row direction, two samples (labeled "In") were taken directly in the row of plants, and two samples (labeled "Between") were taken halfway between the plant rows. In the case of broadcast soybeans, "none" denotes the row spacing.

Investigators attempted to co-locate the bulk density samples with the gravimetric soil moisture sampling points. In cases where these points could not be easily identified, they used approximate locations.

3.2.1.3 Volumetric Soil Moisture (ThetaProbe) Processing

Watershed surface soil moisture was sampled each morning during the experiment. ThetaProbe voltage readings from a row sampling point were compared to the volumetric soil moisture measured at the same point. A regression relationship was developed and new volumetric soil moisture values were estimated.

Field averages were calculated using a simple averaging scheme that counted the quarter row reading twice for a total of four data points per sampling site. A field average was computed by first computing the sampling site average and then computing the average among the (approximately) 14 sampling sites. Finally, standard deviations were calculated.

3.2.2 Error Sources

For various reasons, including extremely dry conditions, severe weather restrictions, miscommunication among personnel, and cultivation, some sites were not sampled on particular days. Occasionally, a ThetaProbe rod was broken because of very hard and dry soil conditions.

When possible, the broken rod was replaced. When it was not possible to replace the rod, a new ThetaProbe was used.

3.3 Sensor or Instrument Description

3.3.1 Manual Soil Collection (Bulk Density and Gravimetric Soil Moisture)

Soil samples were manually collected in the field using spatulas, scoop tools, and soil cans. These samples were used for bulk density and gravimetric soil moisture measurements. Soil samples were weighed with balances and dried in ovens.

3.3.2 Thermometers (Temperature)

The surface temperature was sampled using handheld infrared thermometers, and soil temperature was obtained using a digital thermometer probe inserted to depths of 1 cm, 5 cm and 10 cm. The handheld infrared thermometers were OMEGA OS643-LS Infrared Pyrometers. The instrument has an emissivity of 0.95, accuracy of ± 3%, and temperature range of 0 to 260°C (32 to 500°F). Refer to OMEGA Engineering for more information.

Figure 1 OS643-LS Infrared Pyrometer

ThetaProbes (Volumetric Soil Moisture)

Volumetric soil water content is the ratio between the volume of water present in the soil and the total volume of the sample. Investigators used impedance probes to measure surface volumetric soil moisture, by determination of the apparent dielectric constant.

The probes were Type ML2 ThetaProbe manually-operated impedance instruments manufactured by Delta-T Devices, Ltd. The ThetaProbes have 4 separate 6-cm stainless steel rods inserted vertically into the soil. Each instrument was connected to a handheld reader that delivers the electrical pulse, detects the return signal, and converts the period to voltage between 0 V and about 1 V.

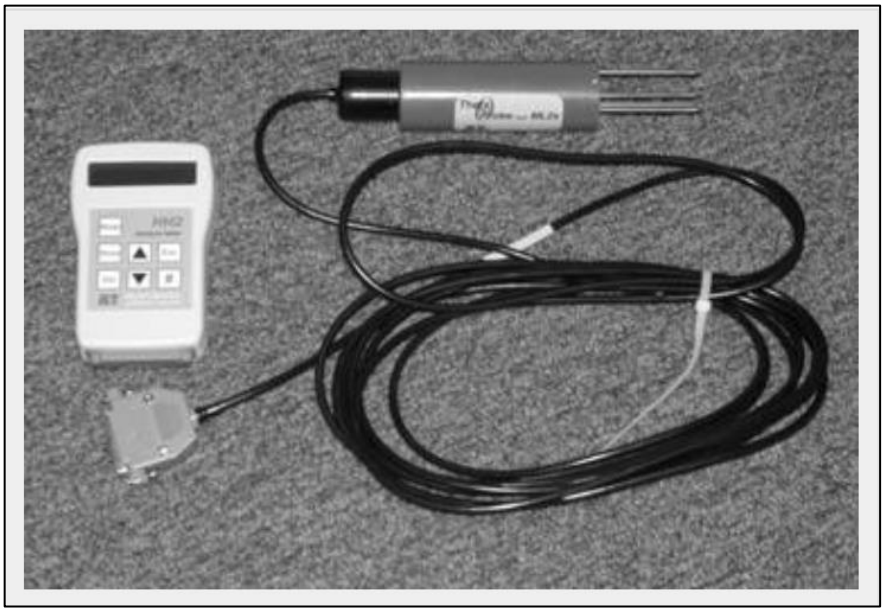


Figure 2 ML2 ThetaProbe and Reader

The software provided by the probe manufacturer calibrates the ThetaProbes by calculating an estimate of volumetric soil moisture according to the following equation:

$$Theta = (1.07 + 6.4V - 6.4V2 + 4.7V3 - a_0) / a_1$$

where the constants a_0 and a_1 depend on soil type and for this experiment are 1.6 and 8.4, respectively. These estimates are provided in the data files.

Researchers also performed soil-specific calibration for each sampling field. ThetaProbe voltage readings from the quarter row sampling point were compared to the volumetric soil moisture measured at the same point. A regression relationship was developed and new volumetric soil moisture values were estimated.

4 REFERENCES AND RELATED PUBLICATIONS

Please see the AMSR-E site to access all validation data

5 CONTACTS AND ACKNOWLEDGMENTS

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6 DOCUMENT INFORMATION

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6.2 Date Last Updated

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