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The documentation for this data set was provided solely by the Principal Investigator(s) and was not further developed, thoroughly reviewed, or edited by NSIDC. Thus, support for this data set may be limited.

SMEX04 Surface Roughness Data



An example of a roughness picture taken in the Walnut Gulch Experimental Watershed during SMEX04

Overview:

Soil surface roughness photos were taken and roughness coefficients were calculated as part of the experiment's site characterization protocol. Surface roughness, correlation length and power coefficients are calculated for each location.

Citing These Data:

The following example shows how to cite the use of this data set in a publication. List the principal investigators, year of data set release, data set title, publisher: NSIDC, and digital media.

Jackson, Thomas J., Lynn McKee, Venkat Lakshmi, and Michael H. Cosh. 2009. *SMEX04 Surface Roughness Data*. Boulder, Colorado USA: National Snow and Ice Data Center. Digital media.

Overview Table

Category	Description
<u>Data format</u>	ASCII tab-delimited text files
<u>Spatial coverage</u>	29.85° N to 32.08° N, 109.71° W to 110.7° W
Temporal coverage	30 July 2004 to 25 August 2004
<u>File naming convention</u>	AZ_roughness.txt contains the Arizona, USA data. SO_roughness.txt contains the Sonora, Mexico data.
<u>File size</u>	6 KB to 30 KB
<u>Parameter(s)</u>	Root mean square error (Sigma), correlation length in mm (L), root mean square error adjusted for slope (Asigma), power coefficient (Corr).
<u>Procedures for obtaining data</u>	Data are available via FTP.

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1. Contacts and Acknowledgments:

Investigator(s) Name and Title:

Thomas J. Jackson, Hydrologist, USDA ARS Hydrology and Remote Sensing Laboratory, Beltsville, MD
Lynn McKee, Soil Scientist, USDA ARS Hydrology and Remote Sensing Laboratory, Beltsville, MD

Venkat Lakshmi, Associate Professor, University of South Carolina
Michael H. Cosh, Hydrologist, USDA ARS Hydrology and Remote Sensing
Laboratory, Beltsville, MD.

Technical Contact:

NSIDC User Services
National Snow and Ice Data Center
CIRES, 449 UCB
University of Colorado
Boulder, CO 80309-0449
phone: (303)492-6199
fax: (303)492-2468
form: [Contact NSIDC User Services](#)
e-mail: nsidc@nsidc.org

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2. Detailed Data Description:

Format:

Two ASCII tab-delimited text files.

AZ_roughness.txt

Column Heading	Description
Site	Field Location and orientation
date of sample	Date of Measurement
N	Number of digitized points
Sigma	Root mean square (rms) error
L	Correlation length in mm
Asigma	Root mean square error adjusted for slope
Corr	Power coefficient
Latitude	WGS 84
Longitude	WGS 84

Northing	WGS 84, UTM in meters, zone 12
Easting	WGS 84, UTM in meters, zone 12

SO_roughness.txt

Column Heading	Description
site	Field Location and orientation
N	Number of digitized points
Sigma	Root mean square error
L	Correlation length in mm
Asigma	Root mean square error adjusted for slope
Corr	Power coefficient
Latitude	WGS 84
Longitude	WGS 84
Northing	WGS 84, UTM in meters, zone 12
Easting	WGS 84, UTM in meters, zone 12

File Naming Convention:

Files are named for the location.

AZ_roughness.txt contains the Arizona soil roughness data.

SO_roughness.txt contains the Sonora soil roughness data.

Spatial Coverage:

Southernmost Latitude: 29.85° N

Northernmost Latitude: 32.08° N

Westernmost Longitude: 110.70° W

Easternmost Longitude: 109.71° W

Temporal Coverage:

Measurements were taken between 30 July 2004 and 25 August 2004.

Temporal Resolution:

Measurements were taken once per site.

The Science

The soil roughness of the SMEX04 dataset is described using three parameters: root mean square height (*rms* height or Sigma); correlation length (*L*); and the power coefficient (*Corr*) of the correlation function $f(L)$. The root mean square height describes the random surface characteristics, while the correlation length and correlation function

describe the periodicity of the soil surface. The correlation function is characterized by a power coefficient n (identified as ‘Corr’ in the data files) ranging from ‘1’ to ‘2’, where ‘1’ represents a Gaussian height distribution and ‘2’ represents an exponential height distribution. The periodicity and random components of the soil surface roughness are schematically shown in figures 1a and 1b.

In terms of the mean surface height (\bar{z}) and the second moment ($\overline{z^2}$), the *rms* height is represented by:

$$rms = \left(\overline{z^2} - \bar{z}^2 \right)^{1/2} \quad \text{Eq. 1}$$

where z is the surface height in cm.

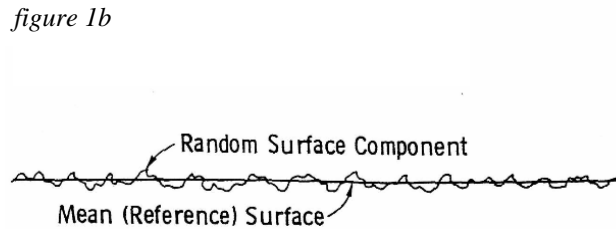
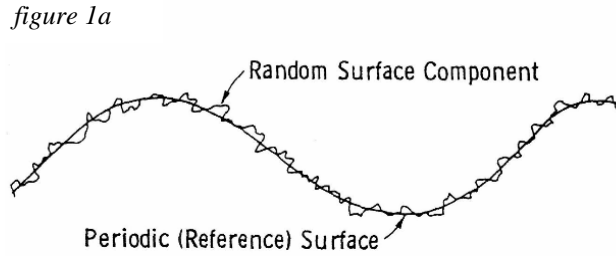


Figure 1a and b, visualization of the two surface roughness components
(after Dobson and Ulaby, 1998).

To determine the correlation length and the correlation function, the surface autocorrelation curve needs to be computed. The surface autocorrelation is a measure of the degree of correlation between the height $z(x)$ at point x and the height $z(x+d)$ at point $x + d$. The following equation can be used to calculate the autocorrelation curve:

$$\rho(d) = \frac{\int z(x)z(x+d)dx}{\int z^2(x)dx} \quad \text{Eq. 2}$$

Once the autocorrelation curve has been computed, the correlation length can be determined. The correlation length is defined as the distance (d) at which the autocorrelation is less than e^{-1} (≈ 0.3678). The computed correlation length can be used to fit the theoretical correlation function to the measured autocorrelation curve by

optimizing the power coefficient (n). The correlation function is mathematically represented by:

$$\rho(d) = \exp\left(\frac{d}{L}\right)^n \quad \text{Eq. 3}$$

where L is the correlation length (cm) and n is the power coefficient describing the correlation function, which is dimensionless.

Sampling Strategy

At each site two representative locations were selected for roughness sampling. At each sampling location, one roughness picture along the row direction and one in the cross-row direction was taken; or in the absence of row structure, the two pictures were taken at perpendicular angles. Thus, for each site 4 grid board pictures (2 locations, 2 pictures per location) should be available.

However, at some roughness sampling sites, one picture was taken and in other cases pictures were missing. Table 1 gives an overview of the number of pictures taken at each experimental site.

Table1, Listing of the roughness pictures made during SMEX04 in Arizona.

Site	Date	Cross rows		Along Rows	
		Site A	Site B	Site A	Site B
	<i>mm/dd/yy</i>				
AZ01	08/13/04	x	x	x	x
AZ02	08/13/04	x	x	x	x
AZ03	08/13/04	x	x	x	x
AZ04	08/15/04	x	x	x	x
AZ05	08/15/04	x	x	x	x
AZ06	08/15/04	x	x	x	x
AZ07	08/15/04	x	x	x	x
AZ08	08/15/04	x	x	x	x
AZ09	08/09/04	x	x	x	x
AZ10	08/04/04	x	x	x	x
AZ11	07/30/04	x	x	x	x
AZ12	08/08/04	x	x	x	x
AZ13	08/08/04	x	x	x	x
AZ14	08/08/04	x	x	x	x
AZ15	08/08/04	x	x	x	x
AZ16	08/08/04	x	x	x	x
AZ17	08/11/04	x	x	x	x
AZ18	08/11/04	x	x	x	x
AZ19	08/11/04	x	x	x	x
AZ20	08/11/04	x	x	x	x

AZ21	08/11/04	x	x	x	x
AZ22	08/12/04	x	x	x	x
AZ23	08/12/04	x	x	x	x
AZ24	08/14/04	x	x	x	x
AZ25	08/12/04	x	x	x	x
AZ26	08/12/04	x	x	x	x
AZ27	08/12/04	x	x	x	x
AZ28	08/12/04	x	x	x	x
AZ29	07/31/04	x	x	x	x
AZ30	08/14/04	x	x	x	x
AZ31	08/14/04	x	x	x	x
AZ32	08/09/04	x	x	x	x
AZ33	08/09/04	x	x	x	x
AZ34	08/09/04	x	x	x	x
AZ35	08/09/04	x	x	x	x
AZ36	08/10/04	x	x	x	x
AZ37	08/10/04	x	x	x	x
AZ38	08/10/04	x	x	x	x
AZ39	08/10/04	x	x	x	x
AZ40	08/10/04	x	x	x	x
RG01	08/04/04	x	x	x	x
RG02	08/04/04	x	x	x	x
RG03	07/30/04	x	x	x	x
RG05	07/30/04	x	x	x	x
RG07	08/04/04	x	x	x	x
RG08	07/30/04	x	x	x	x
RG09	08/25/04	missing	missing	missing	missing
RG10	08/25/04	missing	missing	missing	missing
RG100	08/20/04	x	x	x	x
RG11	08/05/04	x	x	x	x
RG14	08/05/04	x	x	x	x
RG15	08/04/04	x	x	x	x
RG16	08/25/04	missing	missing	missing	missing
RG17	08/05/04	x	x	x	x
RG18	08/05/04	x	x	x	missing
RG19	08/16/04	x	x	missing	missing
RG20	08/23/04	x	x	x	x
RG21	08/02/04	x	x	x	x
RG22	08/02/04	x	x	x	x
RG23	08/23/04	x	x	x	x
RG25	08/23/04	x	x	x	x
RG26	08/23/04	x	x	x	x
RG27	08/24/04	x	x	x	x
RG28	08/14/04	x	x	x	x
RG30	08/23/04	x	x	x	x

RG32	08/18/04	x	x	x	x
RG33	08/14/04	x	x	x	x
RG35	08/20/04	x	x	x	x
RG38	08/18/04	x	x	x	x
RG399	08/22/04	x	x	x	x
RG40	08/19/04	x	x	x	x
RG41	08/20/04	x	x	x	x
RG43	08/18/04	x	x	x	x
RG45	08/19/04	x	x	x	x
RG46	08/19/04	x	x	x	x
RG47	08/20/04	x	x	x	x
RG48	08/20/04	x	x	x	x
RG49	08/20/04	x	x	x	x
RG50	08/18/04	x	x	x	x
RG52	07/31/04	x	x	x	x
RG53	08/19/04	x	x	x	x
RG54	08/18/04	x	x	x	x
RG56	07/31/04	x	x	x	x
RG57	08/19/04	x	x	x	x
RG58	08/19/04	x	x	x	x
RG59	08/19/04	x	x	x	x
RG60	08/17/04	missing	missing	missing	missing
RG62	08/22/04	x	x	x	x
RG63	08/19/04	x	x	x	x
RG64	08/24/04	x	x	x	x
RG65	07/31/04	x	x	x	x
RG66	08/22/04	x	x	x	x
RG67	08/24/04	x	x	x	x
RG69	08/24/04	x	x	x	x
RG70	08/24/04	x	x	x	x
RG74	08/02/04	x	x	x	x
RG76	07/30/04	x	x	x	x
RG79	07/30/04	x	x	x	x
RG82-KEN	08/17/04	x	x	x	x
RG83-LH	08/14/04	x	x	x	x
RG87	08/18/04	x	x	x	x
RG89	08/18/04	x	x	x	x
RG92	08/05/04	x	x	x	x

Table 2. Listing of the roughness pictures made during SMEX04 in Sonora.

Site	Cross rows		Along Rows	
	Site A	Site B	Site A	Site B

01	X	X	X	Missing
02	X	X	X	X
C11	X	X	Missing	Missing
C12	X	X	Missing	Missing
C14	X	X	Missing	Missing
C17	X	X	Missing	Missing
C41	X	X	Missing	Missing
C42	X	X	Missing	Missing
C44	X	X	X	Missing
C45	X	X	X	X
C46	X	X	Missing	Missing
C64	X	X	Missing	Missing
So130	X	X	X	X
So131	X	X	X	X
So132	X	X	X	Missing
So133	X	X	X	X
So134	X	X	X	X
So135	X	X	X	X
So136	X	X	X	X
So138	X	X	X	X
So139	X	X	X	X
So140	X	X	X*	X*
So143	X	X	X	X
So146	X	X	X	Missing
T1	X	X	Missing	Missing
T2	X	X	Missing	Missing

* Extra photos were taken at So140 where there was a significant amount of rock.

Regardless of the number of duplicate pictures for each roughness sampling site, one in-row and one cross-row picture was digitized and used for deriving the roughness parameters.

Digitizing the Pictures

The commercial program SigmaScan pro 4 was used to digitize the roughness pictures. Before scanning, the dimensions of the board were identified in SigmaScan pro 4 using reference points on the board. The soil surface was digitized by taking a height measurement at every 2/3 cm (grid scanning). This scanning method provides a random (or normal) distribution of the surface height, which is required for a correct computation of the *rms* height. However, with this method of scanning some variation in the surface height is neglected, which could influence the computation of the correlation length.

Calculation of the Roughness Parameters

The roughness parameters were calculated by a simple spreadsheet program. Because of the variability in x increment of the digitized surface, the surface was resampled to the nearest 1 mm. The root mean square error was then calculated. Correlation length was calculated as the length at which the autocorrelation function is equal to 1/e. The power coefficient was determined by visual comparison of the autocorrelation curves and idealized power curves with some guidance by the root mean square error between the curves.

Limitations of the Dataset

The roughness parameters are probably the most unreliable parameter in the process of soil moisture retrieval using microwave remote sensing. The first problem is that the scattering characteristics of natural surfaces are very complex and are still not completely understood; this makes validation of measured roughness parameters very difficult.

Second, the scale at which roughness is measured and the scale at which roughness affects microwave backscatter and emission are not the same. The typical resolution of microwave instruments is around or above 10 meters, while the grid board is only 1 meter long. The values of the *rms* height and the correlation length (*L*) differ at each scale.

3. Data Access and Tools:

Data Access:

Data are available via FTP.

Volume:

File sizes range from 6 KB to 30 KB.

Software and Tools:

No special tools are required to view these data.

Related Data Collections:

For related data collections, please see AMSR-E Validation:
http://nsidc.org/data/amsr_validation/.

4. References and Related Publications:

Dobson, M. C. and F. T. Ulaby. 1998. Mapping soil moisture distribution with imaging radar, 407- 430. In: Henderson, F. M. and A. J. Lewis, 1998, Principles & Application of imaging radar, John Wiley & Sons, New York.

5. Document Information:

List of Acronyms

The following acronyms are used in this document:

AMSR-E - Advanced Microwave Scanning Radiometer - Earth Observing System

SMEX - Soil Moisture Experiments

USDA - United States Department of Agriculture

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