**Notice to Data Users:**
**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, and publisher.

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

## Overview Table

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

## Table of Contents



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## Acknowledgements:

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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 W | GS 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 W | GS 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_roughenss.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:

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

where *z* is the surface height in cm.

*figure 1a*

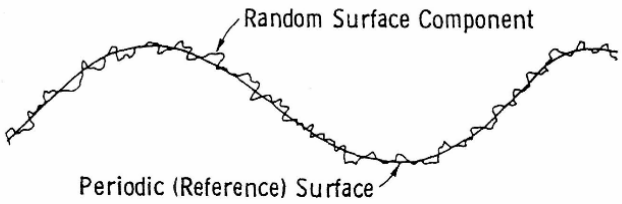


*figure 1b*

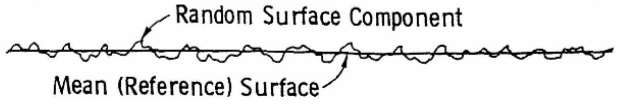


Figure 1a and b, visualization of the two surface roughness components (after Dobson and Ulaby, 1998).

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:

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

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 $e^{-1}$ ($\approx 0.3678$). 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:

$$\rho(d) = \exp\left(d/L\right)^n \qquad \textbf{Eq. 3}$$

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 | |
|---|---|---|---|---|---|
| | *mm/dd/yy* | Site A | Site B | Site A | Site B |
| 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 m | issing m | issing |
| RG10 | 08/25/04 | missing | missing m | issing m | issing |
| 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 m | issing m | issing |
| RG17 | 08/05/04 | x | x x x | | |
| RG18 | 08/05/04 | x | x x m | | issing |
| 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 m | issing m | issing |
| 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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