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Soil Moisture Profiles and Temperature Data from SoilSCAPE Sites, Version 2

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Documentation Revision Date: 2023-02-24

Dataset Version: 2

Summary

This dataset contains in-situ soil moisture profile and soil temperature data collected at 30-minute intervals at SoilSCAPE (Soil moisture Sensing Controller and oPtimal Estimator) project sites since 2021 in the United States and New Zealand. The SoilSCAPE network has used wireless sensor technology to acquire high temporal resolution soil moisture and temperature data over varying durations since 2011. Since 2021, the SoilSCAPE has upgraded the two previously active sites in Arizona and added several new sites in the United States and New Zealand. These new sites typically use the METER Teros-12 soil moisture sensor. At its maximum, the new network consisted of 57 wireless sensor installations (nodes), with a range of 6 to 8 nodes per site. Each SoilSCAPE site contains multiple wireless end-devices (EDs). Each ED supports up to five soil moisture probes typically installed at 5, 10, 20, and 30 cm below the surface. Sites in Arizona have soil moisture probes installed at up to 75 cm below the surface. Soil conditions (e.g., hard soil or rocks) may have limited sensor placement. The data enables estimation of local-scale soil moisture at high temporal resolution and validation of remote sensing estimates of soil moisture at regional and national (e.g. NASA's Cyclone Global Navigation Satellite System - CYGNSS and Soil Moisture Active Passive - SMAP) scales. The data are provided in NetCDF format.

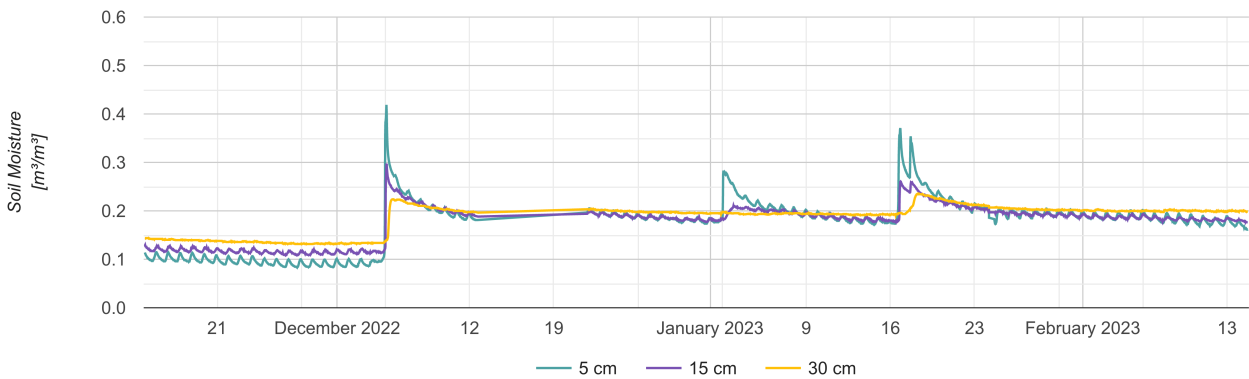This dataset includes 43 files in NetCDF (*.nc) format.

Figure 1. Root zone soil moisture at 5, 15, and 30 cm depth for a node in Lucky Hills, AZ.

Citation

Moghaddam, M., A.R. Silva, D. Clewley, R. Akbar, S.A. Hussaini, J. Whitcomb, R. Shrestha, C.J. Lindsley, T.R. Walker, and B.E. Wilson. 2023. Soil Moisture Profiles and Temperature Data from SoilSCAPE Sites, Version 2. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/2049

Table of Contents

1. Dataset Overview

This dataset contains in-situ soil moisture profile and soil temperature data collected at 30-minute intervals at SoilSCAPE (Soil moisture Sensing Controller and oPtimal Estimator) project sites since 2021 in the United States and New Zealand. The SoilSCAPE network has used wireless sensor technology to acquire high temporal resolution soil moisture and temperature data over varying durations since 2011. Since 2021, the SoilSCAPE has upgraded the two previously active sites in Arizona and added several new sites in the United States and New Zealand. These new sites typically use the METER Teros-12 soil moisture sensor. At its maximum, the new network consisted of 57 wireless sensor installations (nodes), with a range of 6 to 8 nodes per site. Each SoilSCAPE site contains multiple wireless end-devices (EDs). Each ED supports up to five soil moisture probes typically installed at 5, 10, 20, and 30 cm below the surface. Sites in Arizona have soil moisture probes installed at up to 75 cm below the surface. Soil conditions (e.g., hard soil or rocks) may have limited sensor placement.

The data enables estimation of local-scale soil moisture at high temporal resolution and validation of remote sensing estimates of soil moisture at regional and national (e.g. NASA's Cyclone Global Navigation Satellite System - CYGNSS and Soil Moisture Active Passive - SMAP) scales.

Related DataSet

Moghaddam, M., A.R. Silva, D. Clewley, R. Akbar, S.A. Hussaini, J. Whitcomb, R. Devarakonda, R. Shrestha, R.B. Cook, G. Prakash, S.K. Santhana Vannan, and A.G. Boyer. 2017. Soil Moisture Profiles and Temperature Data from SoilSCAPE Sites, USA. ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1339

- This dataset contains data from active SoilSCAPE sites in or prior to 2021. These measurements were typically collected using the EC-5 and 5-TM soil moisture sensors from Decagon Devices.

Related Publication:

Akbar, R., J. Cambell, A.R. Silva, R. Chen, A. Melebari, and E. Hodges, D. Entekhabi, C. Ruf, and M. Moghaddam. 2020. "Soilscape Wireless in Situ Networks in Support of CYNGSS Land Applications," IGARSS 2020 - 2020 IEEE International Geoscience and Remote Sensing Symposium, 2020, pp. 5042-5044, https://doi.org/10.1109/IGARSS39084.2020.9324648.

Dorigo, W., I. Himmelbauer, D. Aberer, L. Schremmer, I. Petrakovic, L. Zappa, W. Preimesberger, A. Xaver, F. Annor, J. Ardö, D. Baldocchi, D. Bitelli, G. Blöschl, H. Bogena, L. Brocca, J.-C. Calvet, J.J. Camarero, G. Capello, M. Choi, M.C. Cosh, N. van de Giesen, I. Hajdu, J. Ikonen, K.H. Jensen, K.D. Kanniah, I. de Kat, G. Kirchengast, P. Kumar Rai, J. Kyrouac, K. Larson, S. Liu, A. Loew, M. Moghaddam, J. Martínez Fernández, C. Mattar Bader, R. Morbidelli, J.P. Musial, E. Osenga, M.A. Palecki, T. Pellarin, G.P. Petropoulos, I. Pfeil, J. Powers, A. Robock, C. Rüdiger, U. Rummel, M. Strobel, Z. Su, R. Sullivan, T. Tagesson, A. Varlagin, M. Vreugdenhil, J. Walker, J. Wen, F. Wenger, J.P. Wigneron, M. Woods, K. Yang, Y. Zeng, X. Zhang, M. Zreda, S. Dietrich, A. Gruber, P. van Oevelen, W. Wagner, K. Scipal, M. Drusch, and R. Sabia. 2021. The International Soil Moisture Network: serving Earth system science for over a decade, Hydrol. Earth Syst. Sci., 25, 5749–5804, https://doi.org/10.5194/hess-25-5749-2021

2. Data Characteristics

Spatial Coverage: USA and New Zealand.

Spatial resolution: Point Locations.

Temporal Coverage: These data cover the period 2021-12-03 to the present. Sampling is continuing at active sites, and data are updated weekly.

Temporal Resolution: 30 minutes

Study Area: (all latitudes and longitudes given in decimal degrees)

Site	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
USA	-110.0532	174.5559	37.19538	-36.70378

Table 1. SoilSCAPE Sites. * Inactive sites.

| Site	Number of nodes	Temperature Measured	Start Date	End Date	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Kendall, AZ, USA	6	Yes	2022-08-17	-	-109.946	-109.940	31.737	31.735
Lucky Hills, AZ, USA	7	Yes	2021-08-15	-	-110.052	-110.053	31.744	31.742
CO-Z1, CO, USA	4	Yes	2021-12-03	-	-105.996	-105.824	37.195	37.055
CO-Z4, CO, USA	1	Yes	2021-12-04	-	-105.824	-105.824	37.055	37.055
JR-1, NM, USA	4	Yes	2022-05-04	-	-106.740	-106.736	32.523	32.516
JR-2, NM, USA	4	Yes	2022-05-04	-	-106.787	-106.778	32.592	32.589
JR-3, NM, USA	4	Yes	2022-05-04	-	-106.741	-106.732	32.613	32.608
Ararimu, NZ	5	Yes	2022-4-20	-	174.555	174.553	-36.701	-36.703
Riverhead, NZ	3	Yes	2022-09-08	-	174.616	174.612	-36.746	-36.714
Wharekapua, NZ	5	Yes	2022-04-23	-	173.057	173.047	-34.717	-34.721
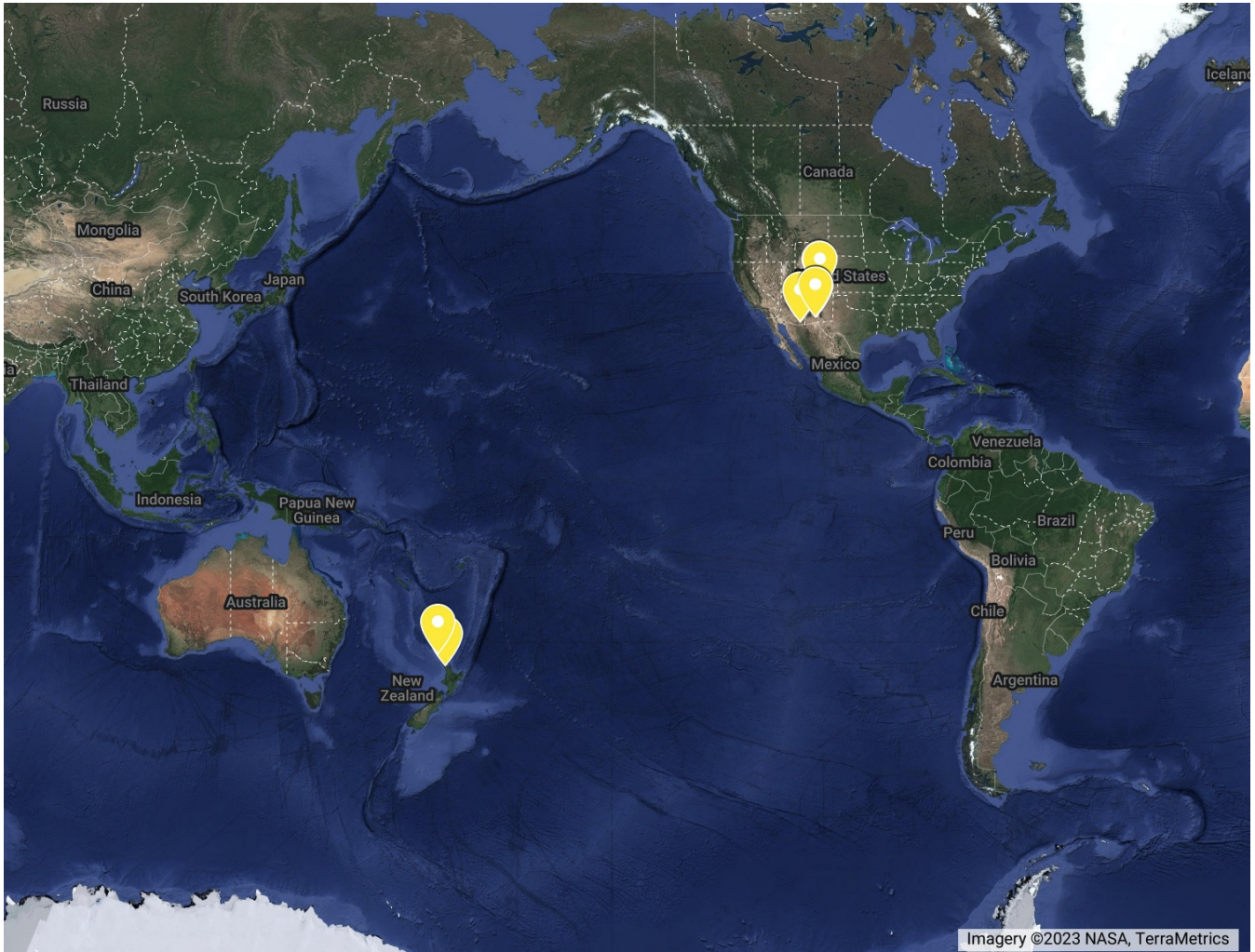
Figure 2. SoilSCAPE site locations.

Data File Information

This dataset includes 43 files in NetCDF format for 30-min interval data for soil moisture and soil temperature. The locations of the sites are provided in Table 1. The file names use the file naming convention of "soil_moist_30min_aaa_XX_nNNNN.nc" where aaa=Name of site (each site contains multiple notes); XX=State or country abbreviations (e.g. CO, NM, NZ); and NNNN is the Node ID (physicalid).

Table 2. Data fields.

Data Field	Units	Description
time	minutes since 2011-01-01	Date and time of the data collection
physicalid		Physical identifier of the node
lat	decimal degrees	Latitude of the node
lon	decimal degrees	Longitude of the node
soil_moisture	m3/m3	Volumetric soil moisture at various soil depths in m^3/m^3.
soil_quality_bit		A four-digit binary flag for soil moisture. • char 1 = if 1, Low Device Battery (< 3.2V) • char 2 = if 1, Sensor probe over current • char 3 = if 1, Sensor Not Detected • char 4 = if 1, Invalid Data
soil_quality_flag		One-digit soil moisture flag. • 0: Recommended for use • 1: Not recommended for use
depth	cm	Depth at which the soil moisture and temperature sensors are placed
sensor		Type of the soil moisture sensor (e.g., Teros-12)
temperature	degrees Celsius (C)	Soil temperature at various soil depths

temp_quality_bit		A four-digit binary flag for soil temperature. • char 1 = if 1, Low Device Battery (< 3.2V) • char 2 = if 1, Sensor probe over current • char 3 = if 1, Sensor Not Detected • char 4 = if 1, Invalid Data
temp_quality_flag		One-digit soil temperature flag. • 0: Recommended for use • 1: Not recommended for use

3. Application and Derivation

This dataset can be used for:

(1) Generation of local scale estimates of soil moisture at high temporal resolution. The point measurements from the sensor are scaled up to regional level hydrological models to produce local estimates of soil moisture.

(2) Validation of remote sensing based estimates of soil moisture. Soil moisture information from various SoilSCAPE sites will be used by various NASA Cyclone Global Navigation Satellite System (CYGNSS) Science Team members for soil moisture product calibration, validation, and assessment.

4. Quality Assessment

Uncertainty in the data was not quantified. The data were calibrated using site specific calibration equations and mineral soil calibration See more details in Akbar et al. (2020).

Quality flags for soil moisture/temperature are provided in data files (0=recommended and 1 = not recommended for use). Additional quality bit information of the probe status are also provided as separate variables. For more details, see Table 2.

5. Data Acquisition, Materials, and Methods

The soil moisture sensors were typically METER Teros-12 installed at different depths (usually at 5, 10, 20, and 30 cm) below the soil surface. Sites in Arizona have soil moisture probes installed up to 75 cm below the surface. The sensor was held in place by fastening it to a t-post. A barbed wire fence was also installed around the sensor at some locations to prevent damage from grazing cattle.

The sensors communicated with a local coordinator which wirelessly sent the data to the data server located at the University of Southern California (Figure 3).

The optimal placement of the sensors in time and space is achieved using the steady-state soil moisture statistics and surface state distribution of soil moisture in the area of interest weighed against the cost of communication associated with the sensor placement. The system uses the wireless sensor architecture called Ripple (Silva et al., 2012), which has undergone a number of improvements over the years.
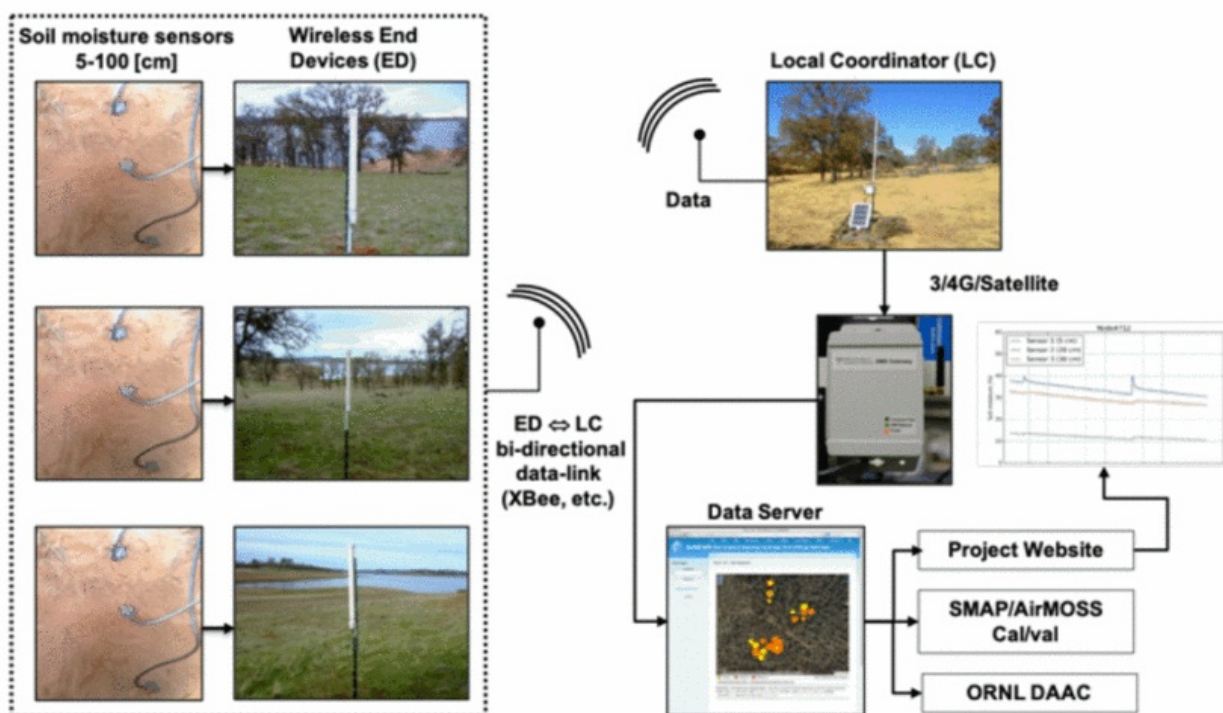

Figure 3. The wireless architecture of the SoilSCAPE network (Akbhar et al., 2020).

6. Data Access

These data are available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

[Soil Moisture Profiles and Temperature Data from SoilSCAPE Sites, Version 2](#)

Contact for Data Center Access Information:

- E-mail: uso@daac.ornl.gov
- Telephone: +1 (865) 241-3952

7. References

Akbar, R., J. Cambell, A.R. Silva, R. Chen, A. Melebari, and E. Hodges, D. Entekhabi, C. Ruf, and M. Moghaddam. 2020. "Soilscape Wireless in Situ Networks in Support of Cyngss Land Applications," IGARSS 2020 - 2020 IEEE International Geoscience and Remote Sensing Symposium, 2020, pp. 5042-5044, https://doi.org/10.1109/IGARSS39084.2020.9324648.

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8. Dataset Revisions

Version	Description	Published
2	This is the Version 2 release of the dataset, which contains data from active SoilSCAPE sites since 2021. These measurements were typically collected using the METER Teros-12 soil moisture sensor. The data will continuously be updated on a weekly interval.	2023-02-24
1	Soil Moisture Profiles and Temperature Data from SoilSCAPE Sites . This is the Version 1 release of the dataset which contains data from active SoilSCAPE sites in or prior to 2021. These measurements were typically collected using the EC-5 and 5-TM soil moisture sensors from Decagon Devices.	2016-09-16

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