SMAPVEX15 PALS Soil Moisture Data, Version 1

USER GUIDE

How to Cite These Data

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

Colliander, A., Misra, S., and M. Cosh. 2022. *SMAPVEX15 PALS Soil Moisture Data, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/SUCCVWOBL6RQ. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SV15PLSM/

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DATA DESCRIPTION

1.1 Parameters

The main parameter for this data set is volumetric soil moisture [m^3/m^3]. Inputs to the algorithm are also provided, including estimated soil temperature [°C], estimated vegetation temperature [°C], vegetation water content [kg/m^2], land cover class, sand fraction [%], and clay fraction [%].

1.1.1 Parameter Range

Valid parameter values are as follows:

Soil moisture: 0–1m^3/m^3

Temperature: 0–40°C

Vegetation water content: 0–40 kg/m^2

Sand and clay fractions: 0–100%

Table 1 describes the land cover classes, which range from 3 to 11 in this data set.

Table 1. Land Cover Classes

Class Number	Description
3	Urban
4	Shrub
6	Grass, forage crops, fallow
10	Crops
11	Forest

1.2 File Information

1.2.1 Format

Data are provided in Comma Separated Values (CSV) files. Table 2 provides descriptions for each column in the CSV files.

An associated Extensible Markup Language (XML) metadata file is also provided for each data file.

Table 2. Description of Columns in Data Files

Column Number	Column Heading	Column Description
1	Date	Date in YYYYMMDD format [4-digit year, 2-digit month, 2-digit day]
2	Row	Row number of grid
3	Col	Column number of grid
4	Lat	Latitude of grid cell center [degrees latitude]
5	Lon	Longitude of grid cell center [degrees longitude]
6	VSM	Volumetric soil moisture [m^3/m^3]
7	Tsoil	Soil temperatures used for soil moisture retrieval [°C]
8	Tveg	Vegetation temperature used for soil moisture retrieval [°C]
9	VWC	Vegetation water content used for soil moisture retrieval [kg/m^2]
10	LC	Land cover classification used for soil moisture retrieval [*]
11	S%	Soil sand fraction used for soil moisture retrieval [%]
12	C%	Soil clay fraction used for soil moisture retrieval [%]
Note: The fill value -9999 indicates when no data are available.		

1.2.2 Directory Structure

Data are available via HTTPS in the following directory:

https://n5eil01u.ecs.nsidc.org/SMAP_VAL/SV15PLSM.001/

1.2.3 Naming Convention

Files are named according to the following convention and as described in Table 3:

```
SV15PLSM_PALS_VSM_WG_M500_[vXXX]_[YYYYMMDD]_[scan].csv
```

Example file name:

```
SV15PLSM_PALS_VSM_WG_M500_v040_20150802_both.csv
```

Table 3. File Naming Convention

Variable	Description
SV15PLSM	Product Short Name
PALS	Passive Active L-band System (PALS) Data
VSM	Volumetric Soil Moisture
WG	Walnut Gulch
M500	500 m (grid resolution)
vXXX	Data Version (v040: Version 0.40)

YYYYMMDD	4-digit year, 2-digit month, 2-digit day
[scan]	Indicates the part of the conical scan included in the processing (fore, aft, both)
.csv	Indicates CSV file format

1.3 Spatial Information

1.3.1 Coverage

Southernmost Latitude: 31.51°N

Northernmost Latitude: 31.87°N

Westernmost Longitude: 110.96°W

Easternmost Longitude: 109.84°W

1.3.2 Resolution

The high altitude footprint size is approximately 1200m. The data are gridded on a 500m grid.

1.3.3 Projection

Data are provided in Universal Transverse Mercator (UTM) World Geodetic System 1984 (WGS84) coordinates.

1.4 Temporal Information

1.4.1 Coverage

Data were collected every two to three days from 02 August 2015 through 18 August 2015.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

The NASA SMAP (Soil Moisture Active Passive) mission conducted the SMAP Validation Experiment 2015 (SMAPVEX15) to support calibration and validation efforts of SMAP soil moisture data products. To address concerns about the spatial disaggregation methodologies, SMAPVEX15 sought to improve soil moisture products and validate in situ measurement upscaling processes. To support these objectives, high-resolution soil moisture maps were acquired and intensive ground sampling efforts carried out, over an area in southeast Arizona that includes the Walnut Gulch Experimental Watershed (WGEW).

2.2 Acquisition

The PALS instrument collects coincident (in time and place) radar and radiometer measurements. Both measurements are acquired using the same antenna in a fast-switching sequence (Wilson et al, 2001).

PALS has been used in several previous soil moisture studies (e.g., Njoku et al., 2002; Narayan et al., 2004; Bindlish et al., 2009; Colliander et al., 2012, 2015, 2016; Barber et al., 2016). During SMAPVEX15, PALS was installed on a DC-3 aircraft. In its 2015 configuration, PALS used a lightweight antenna with a 21° beamwidth which included a scanning mechanism. The PALS antenna was attached to a scan head under the fuselage of the aircraft allowing a full 360° conical scan at 40° incidence angle to match the observing angle of SMAP. This design results in a footprint of 1100m (along scan) by 1500m (radially) on the ground with an effective resolution of about 1200m (square root of the area of the footprint ellipse) for the flights at 2300m altitude above ground.

The operation of the PALS radiometer is based on a two-reference switching scheme (Wilson et al, 2001); this design was adopted for the radiometers deployed by the SMAP (Piepmeier et al., 2017) and Aquarius (Le Vine et al., 2007) missions. One of the references is a matched load; the other one is a noise diode. These two loads allow the removal of internal gain and offset fluctuation of the radiometer chain during operation. The brightness temperature at the input of the antenna is computed using the principles presented by Tanner et al. (2003). In general, water bodies are reliable and widely used calibration targets for airborne low-frequency radiometers. For SMAPVEX15, however, suitable water bodies were not available in the vicinity of the flight path (long transit times limited the flight range available for water body calibrations) to track co-incident relative calibration with science flights. An external absorber load at ambient temperature and a sky reflection were measured before and after each flight to test the repeatability of the calibration. These external measurements were suitable for tracking major relative calibration changes in the radiometer. A separate lake overflight was conducted to tie the relative target measurements to absolute values.

2.3 Algorithms

The soil moisture algorithm uses vertically polarized brightness temperature, the tau-omega model for the vegetation compensation, and the single parameter (h) model for roughness correction. A detailed description of the algorithm is provided in Colliander et al. (2017).

2.4 Processing

Brightness temperatures and other input data are first sampled on the uniform grid. The algorithm is then executed and the output posted on the same grid along with the input data. Refer to Colliander et al. (2017) for more information on processing steps.

2.5 Quality, Errors, and Limitations

2.5.1 Error Sources

Refer to Colliander et al. (2017) for a detailed discussion about error sources impacting the soil moisture retrieval.

2.5.2 Quality Assessment

Colliander et al (2017) reports the following validation metrics using in situ soil moisture measurements:

- Bias: 0.003 m^3/m^3
- Pearson correlation: 0.83
- Root mean square difference (RMSD): 0.016 m^3/m^3
- Unbiased RMSD: 0.016 m^3/m^3

2.6 Instrumentation

2.6.1 Description

With NASA support, the Jet Propulsion Laboratory (JPL) designed, built, and tested the Passive Active L-band System (PALS) microwave aircraft instrument and deployed the instrument for measurements of soil moisture and ocean salinity (Wilson et al. 2001). PALS provides radiometer products, such as vertically and horizontally polarized brightness temperatures, and radar products, including normalized radar backscatter cross-section for V-transmit/V-receive (VV); V-transmit/H-receive (VH); H-transmit/H-receive (HH); and H-transmit/V-receive (HV). In addition, PALS can also provide the polarimetric third Stokes parameter measurement for the radiometer and the complex correlation between any two of the polarized radar echoes.

The following table provides the key characteristics of PALS:

Table 4. Description of the PALS instrument

Passive	Frequency	1.413 GHz
	Polarization	V, H, +45, -45

	Calibration stability	1 K (bias); 0.2 K (stability)
Active	Frequency	1.26 GHz
	Polarization	VV, HH, VH, HV
	Calibration accuracy	<2 dB (bias); 0.2 dB (stability)
Antenna	Half Power Beamwidth	20° (passive); 23°(active)
	Beam Efficiency	94%
	Directivity	18.5 dB
	Polarization isolation	> 35 dB

The PALS instrument was flown in five major soil moisture experiments—SGP99, SMEX02, CLASIC07, SMAPVEX08 (Colliander et al. 2012), and SMAPVEX12 (Colliander et al. 2015)—before being deployed in SMAPVEX15. Beginning with CLASIC07, a new flat-panel antenna array was substituted for the large horns. The planar antenna consists of 16 stacked-patch microstrip elements arranged in four by- four array configurations. Each stacked-patch element uses a honeycomb structure with extremely low dielectric loss at L-band to support the ground plane and radiating patches. The measured antenna pattern shows better than 33 dB polarization isolation, far exceeding the need for the polarimetric measurement capability. This compact, lightweight antenna has enabled PALS to transition to operating on small aircraft such as the Twin Otter (Yueh et al. 2008).

PALS was mounted at a 40° incidence angle looking to the rear of the aircraft. The 3 dB spatial resolutions of the instruments at two potential altitudes are: 500 m, due to the 1000 m altitude minimum for radar operation; and 1500 m, at the 3000 m altitude maximum. It is important to note that PALS provides a single beam of data along a flight track and that any mapping must rely upon multiple flight lines spaced at the footprint width.

The calibration of the PALS brightness temperature during SMAPVEX15 is described in more detail in Colliander et al. (2017).

3 SOFTWARE AND TOOLS

Any word-processing program or Web browser will display these data. No special tools are required.

4 CONTACTS AND ACKNOWLEDGMENTS

Andreas Colliander
Jet Propulsion Laboratory
California Institute of Technology

Sidharth Misra
Jet Propulsion Laboratory
California Institute of Technology

Michael Cosh
Hydrology and Remote Sensing Laboratory
US Department of Agriculture

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6 DOCUMENT INFORMATION

6.1 Publication Date

March 2022

6.2 Date Last Updated

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