SMAPVEX16 Iowa PALS Brightness Temperature and 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., S. Misra, and M. Cosh. 2019. *SMAPVEX16 Iowa PALS Brightness Temperature and 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/10.5067/0DJCHZKY1NVO. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SV16I_PLTBSM

National Snow and Ice Data Center

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1 DATA DESCRIPTION

This product contains data derived from permanent in situ soil stations and observations by the Passive Active L-band System (PALS) microwave aircraft instrument. The PALS instrument was mounted to a DC-3 aircraft, which flew six parallel flight lines at an altitude of 3000 m in order to map a study area in South Fork, Iowa, United States. A total of 20 soil stations were distributed throughout this same area.

The soil characteristics included in this data set are volumetric soil moisture, vertically and horizontally polarized brightness temperature, effective soil temperature, effective vegetation temperature, vegetation water content, land cover classification, sand and clay fraction, and volumetric soil moisture uncertainty estimates.

1.1 Parameters

The contents of the data set are described in Table 1; the main parameters are listed in columns 7 through 16.

Table 1. Data File Contents

Column Number	Column Title	Description	Range	Units
1	Date	Date	2016-05-28 to 2016-08-16	N/A
2	SecUTC	Time of flight, measured from the start of the day	0 – 86400	Seconds UTC
3	Row	EASE-Grid row	1 – 72	N/A
4	Col	EASE-Grid column	1 – 72	N/A
5	Lat	Latitude of the grid pixel center	42.2827 to 42.6580	° N
6	Lon	Longitude of the grid pixel center	-93.5762 to -93.2080	° W
7	VSM	Volumetric soil moisture	0.03 – 0.56	m^3/m^3
8	TAV	Vertically polarized brightness temperature	188 – 295	K
9	TAH	Horizontally polarized brightness temperature	126 – 297	K
10	T_{soil}	Effective soil temperature	12 – 26	°C
11	T_{veg}	Effective vegetation temperature	12 – 26	°C
12	VWC	Vegetation water content	0 – 8	kg/m^2

Column Number	Column Title	Description	Range	Units
13	LC	Land cover class	*Refer to Table 2*	N/A
14	S%	Sand fraction	10 – 80	%
15	C%	Clay fraction	10 – 65	%
16	VSM err	Volumetric soil moisture uncertainty estimate	0.005 – 0.800	m^3/m^3

Table 2. Land Cover Classifications

Value	Land Cover
1	Unclassified
3	Urban
6	Grassland, Pasture
7	Cereal Crops
8	Corn
9	Canola
10	Soybean
11	Broadleaf Trees

1.2 File Information

1.2.1 Format

Data are provided in text (.txt) files and can be accessed through any software capable of reading ASCII text.

Extensible Markup Language (.xml) files with associated metadata are also provided.

1.2.2 File Contents

Figure 1 shows ten lines of sample data and column headers.

Date	SecUTC	Row	Col	Lat	Lon	VSM	TAV	TAH	Tsoil	Tveg	VWC	LC	S%	C%	VSM err
20160813	55671	1	1	42.2827	-93.5762	0.3183	270.19	254.87	22	22	4.05	8	42	22	0.0326
20160813	55670	1	2	42.2827	-93.5711	0.2898	270.27	256.08	22	22	3.76	8	42	24	0.0214
20160813	55666	1	3	42.2827	-93.5659	0.2797	271.28	257.2	22	22	3.74	8	42	28	0.0204
20160813	55665	1	4	42.2827	-93.5607	0.3069	271.68	258.68	22	22	4.58	8	42	31	0.0357
20160813	55667	1	5	42.2827	-93.5555	0.3257	272.46	259.22	22	22	4.84	8	42	31	0.0337
20160813	55672	1	6	42.2827	-93.5503	0.3266	272.44	258.2	22	22	4.24	8	41	31	0.0315
20160813	55675	1	7	42.2827	-93.5451	0.3347	271.71	257.03	22	22	3.47	10	40	31	0.0611
20160813	55675	1	8	42.2827	-93.5399	0.3361	271.89	257	22	22	3.75	10	38	31	0.0782
20160813	55673	1	9	42.2827	-93.5348	0.3415	272.11	259.67	22	22	4.6	8	37	31	0.0329
20160813	55667	1	10	42.2827	-93.5296	0.3184	271.36	261.03	22	22	5.15	8	37	31	0.0365

Figure 1. Sample Data

1.2.3 Naming Convention

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

SV16I_PLTBSM_PALS_VSM_[dom][alt]_XXXX_vYYY_vZZZ_2016MMDD_[scan].txt

Table 3. File Naming Convention

Variable	Description
SV16I_PLTBSM	Short name for SMAPVEX16 Iowa PALS Brightness Temperature and Soil Moisture Data
dom	Short name for experiment domain, SF = South Fork, Iowa
alt	Designation for high altitude or low altitude flights [hi/lo]
XXXX	Grid version (e.g. M500)
YYY	Brightness temperature version (e.g. 033)
ZZZ	Soil moisture version (e.g. 064)
MM	Month
DD	Day
scan	The part of the conical scan included in the processing (fore/aft/both)

1.2.4 File Size

Text files are approximately 596 KB.

1.3 Spatial Information

1.3.1 Coverage

Northernmost Latitude: 42.66° N
Southernmost Latitude: 42.28° N
Easternmost Longitude: 93.21° W
Westernmost Longitude: 93.58° W

1.3.2 Resolution

Data are projected onto a 500 m x 500 m grid.

1.3.3 Geolocation

These data are provided on the global cylindrical EASE-Grid 2.0 (Brodzik et al. 2012). Each grid cell has a nominal area of approximately 500 m x 500 m.

The following tables provide information for geolocating this data set

Table 4. Geolocation Details

Geographic coordinate system	WGS 84
Projected coordinate system	NSIDC EASE-Grid 2.0 Global
Longitude of true origin	0
Standard Parallel	±30
Scale factor at longitude of true origin	N/A
Datum	WGS 1984
Ellipsoid/spheroid	WGS 84
Units	Meter
False easting	0
False northing	0
EPSG code	6933
PROJ4 string	+proj=cea +lon_0=0 +lat_ts=30 +x_0=0 +y_0=0 +ellps=WGS84 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs
Reference	https://epsg.io/6933

Table 5. Grid Details

Grid cell size (x, y pixel dimensions)	500 m
Number of rows	72
Number of columns	72
Geolocated lower left point in grid	49.3649° N, 98.1198° W
Nominal gridded resolution	500 m
Grid rotation	N/A
ulxmap – x-axis map coordinate of the center of the upper-left pixel (XLLCORNER for ASCII data)	49.7882° N
ulymap – y-axis map coordinate of the center of the upper-left pixel (YLLCORNER for ASCII data)	98.1172° W

1.4 Temporal Information

1.4.1 Coverage

Data were collected between 28 May 2016 and 16 August 2016.

2 DATA ACQUISITION AND PROCESSING

2.1 Acquisition

This product includes data derived from 20 permanent in situ soil station measurements and observations by the Passive Active L-band System (PALS) microwave aircraft instrument. Soil moisture stations were distributed throughout the experiment domain (Figure 2). The PALS instrument was mounted to a DC-3 aircraft at a 40° incidence angle. The aircraft was then flown over the experiment domain at an altitude of 3000 m; the 3 dB spatial resolution of the instrument at this flight altitude was approximately 1500 m.

Since PALS provides a single beam of data along a flight track, mapping relies upon multiple flight lines spaced approximately one footprint's width apart. A total of six high-altitude flight lines were used to cover the domain, which has an area of approximately 31 km x 42 km; the lines were spaces approximately 5.3 km apart (Figure 2).

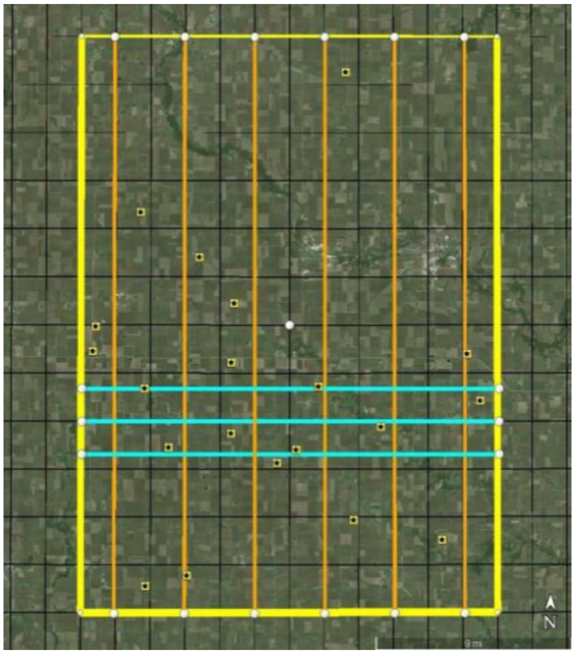

Figure 2. PALS flight lines drawn on Google Earth. High-altitude (3000 m) mapping lines are marked with orange and the low-altitude (1200 m) high resolution lineso are marked with light blue. Also shown is the validation grid (yellow) and permanent *in situ* soil moisture stations.

2.2 Processing

2.2.1 Volumetric Soil Moisture (VSM):

VWM was derived from PALS brightness temperature measurements through an algorithm, which relied on additional data sources as input. Neither the algorithm nor the additional inputs are described in this guide.

2.2.2 Vertically and Horizontally Polarized Brightness Temperature:

Brightness temperature was measured using the airborne PALS instrument.

2.2.3 Effective Soil Temperature:

Effective soil temperature was estimated from in situ soil temperature measurements taken throughout the domain. For each PALS over pass, soil temperature was averaged across each grid cell.

2.2.4 Effective Vegetation Temperature:

Effective vegetation temperature was assumed to be the same as the effective soil temperature.

2.2.5 Vegetation Water Content (VWC):

VWC was estimated from optical satellite observations calibrated with in situ measurements. Least squares fitting was used for each crop class to derive a relationship between the optical index (NDWI) and measured VWC.

2.2.6 Land Cover Class:

Land cover classification maps were based on multiple data sources, which are not described here.

2.2.7 Sand and Clay Fraction:

Sand and clay fraction maps were extrapolated from point-wise field samples and geographical features, which are not described here.

2.2.8 Volumetric Soil Moisture (VSM) Uncertainty Estimate:

VSM uncertainty was estimated using a Monte Carlo method based on magnitude estimates for the different error sources.

2.3 Quality, Errors, and Limitations

2.3.1 Volumetric soil moisture (VSM):

The quality of the soil moisture retrievals was assessed using manually collected in situ soil moisture measurements. Though the retrievals and manual measurements were consistent, the in situ measurements represent soil moisture at the field scale (about 800 m), while the resolution of the soil moisture retrievals is about 1500 m. Therefore, the assessment suffers from spatial representation uncertainty. However, the VSM uncertainty estimates show that the uncertainty of the soil moisture retrieval is within reasonable limits (90% of the data has an uncertainty less than 0.04 m3/m3).

Error sources include any uncertainties related to brightness temperature measurements, ancillary data sets, and/or formulation of the algorithm used to estimate soil moisture.

2.3.2 Vertically and Horizontally Polarized Brightness Temperature:

The quality of the brightness temperature measurements relies on internal calibration of the PALS instrument utilizing matched loads and external targets verifying the repeatability of the measurements. These references assure generally good quality of the data. Additionally, the measurements were compared to the SMAP measurements over the domain; a high degree of consistency was seen between the two measurements. A small adjustment was made to match the PALS measurements to the SMAP measurements at the SMAP footprint scale.

Brightness temperature was subject to random or systematic errors arising from the noise of the PALS receiver, calibration uncertainties, and gridding uncertainties.

2.3.3 Effective Soil Temperature:

Errors include 1) the differences between the measured soil temperature and the actual soil temperature in the pixel and 2) the vertical representation of the measured soil temperature with respect to the actual effective soil temperature, which is a function of vertical temperature and dielectric constant distribution in the soil.

2.3.4 Effective Vegetation Temperature:

Effective vegetation temperature was assumed to be the same as the effective soil temperature; this assumption introduces errors since vegetation temperature evolves differently than soil temperature.

2.3.5 Vegetation Water Content (VWC):

The quality of the VWC was assessed using in situ measurements. Potential sources of errors include field sample representation errors, which were used to determine VWC, and field-to-field variations of the NDWI and VWC relationship.

2.3.6 Land Cover Class:

The various data sources used to assign land cover classification each had their own sources of error, not described here.

2.3.7 Sand and Clay Fraction:

Erroneous extrapolation from point-wise field samples and geographic features may have occurred.

2.3.8 Volumetric Soil Moisture Uncertainty Estimate:

VSM uncertainty was estimated using a Monte Carlo method based on magnitude estimates for the different error sources; errors in the magnitude estimates result in under- or overestimation of the soil moisture retrieval uncertainty. Overall, the quality of the Monte Carlo simulations depends on the representativeness of the error components and their magnitudes, as well as the structural accuracy of the algorithm. The error magnitudes used were comparable to what has been seen in the literature.

2.4 Instrumentation

2.4.1 Description

The campaign deployed the Jet Propulsion Laboratory (JPL), with NASA support, designed, built and tested precision Passive Active L-band System (PALS) microwave aircraft instrument for measurements of soil moisture and ocean salinity (Wilson et al. 2001) (Figure 3). PALS provides radiometer products, vertically and horizontally polarized brightness temperatures, and radar products, normalized radar backscatter cross-section for V- transmit/V-receive, V-transmit/H-receive, H-transmit/H-receive, and H-transmit/V-receive. In addition, it can also provide the polarimetric third Stokes parameter measurement for the radiometer and the complex correlation between any two of the polarized radar echoes (VV, HH, HV and VH). Table 6 provides the key characteristics of PALS.

Table 6. Description of the PALS Instrument

Passive	Frequency	1.413 GHz
	Polarization	V, H, +45, -45
	Calibration stability	0.5 K
Active	Frequency	1.26 GHz
	Polarization	VV, HH, VH, HV
	Calibration stability	0.2 dB
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 six major soil moisture experiments (SGP99, SMEX02, CLASIC07, SMAPVEX08, SMAPVEX12, and SMAPVEX15 [Bolten et al. 2003, Colliander et al. 2012, McNairn et al. 2015]) before deployment in SMAPVEX16. 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 a four-by-four array configuration. The measured antenna pattern shows better than 33 dB polarization isolation, far exceeding the need for the polarimetric measurement capability. This compact, lightweight antenna enabled PALS to transition to operating on small aircrafts (Yueh et al. 2008), but also enabled the conical scan operation implemented for the SMAPVEX15 (Colliander et al. 2017).

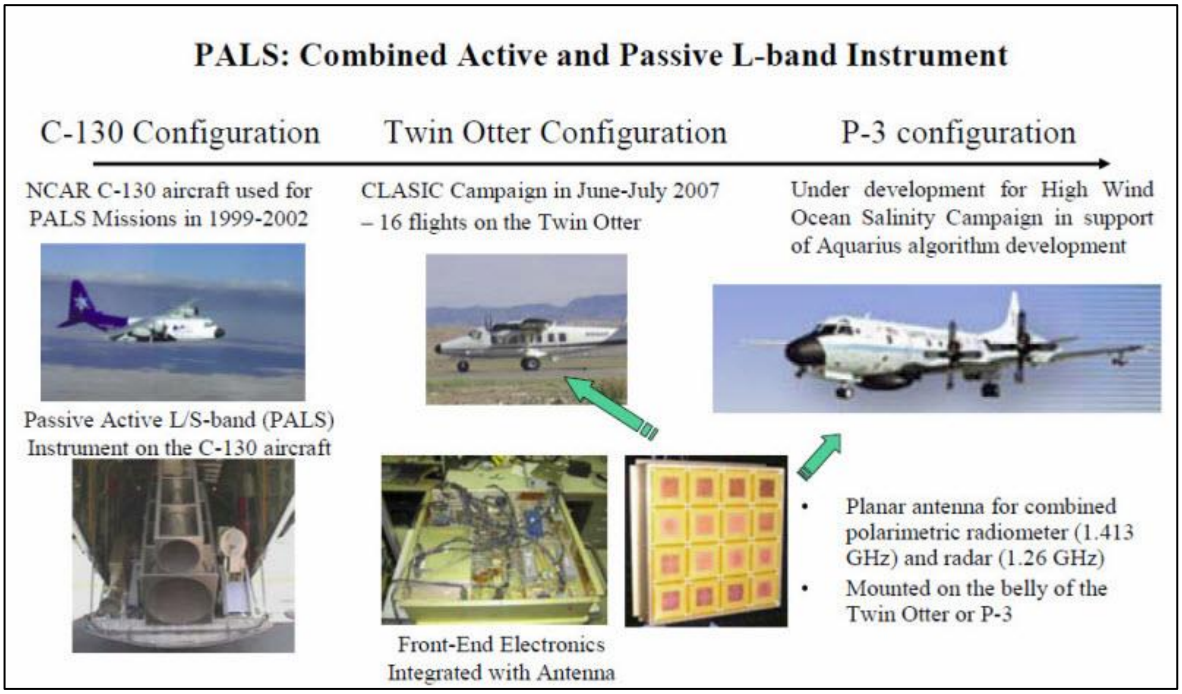

Figure 3. Images of Three Different Aircraft Installations of the PALS Combined Active and Passive L-band Instrument

3 RELATED DATA SETS

SMAP Data | Overview

4 RELATED WEBSITES

SMAP at NASA
SMAPVEX16

5 CONTACTS AND ACKNOWLEDGMENTS

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7 DOCUMENT INFORMATION

7.1 Publication Date

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7.2 Date Last Updated

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