SMAP Enhanced L2 Radiometer Half-Orbit 9 km EASE-Grid Soil Moisture, Version 2

USER GUIDE

How to Cite These Data

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

O'Neill, P. E., S. Chan, E. G. Njoku, T. Jackson, and R. Bindlish. 2018. *SMAP Enhanced L2 Radiometer Half-Orbit 9 km EASE-Grid Soil Moisture, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/K4A1SNL5DLON. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SPL2SMP_E

National Snow and Ice Data Center

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1 DATA DESCRIPTION

1.1 Parameters

Surface soil moisture (0-5 cm) in m3/m3 derived from brightness temperatures (TBs) is output on a fixed global 9 km EASE-Grid 2.0. Also included are brightness temperatures in kelvin representing Level-1B brightness temperatures interpolated at a 9 km EASE-Grid 2.0 cell.

Refer to the Product Specification Document for details on all parameters.

1.2 File Information

1.2.1 Format

Data are in HDF5 format. For software and more information, including an HDF5 tutorial, visit the HDF Group's HDF5 Web site.

1.2.2 File Contents

As shown in Figure 1, each HDF5 file is organized into the following main groups, which contain additional groups and/or data sets:

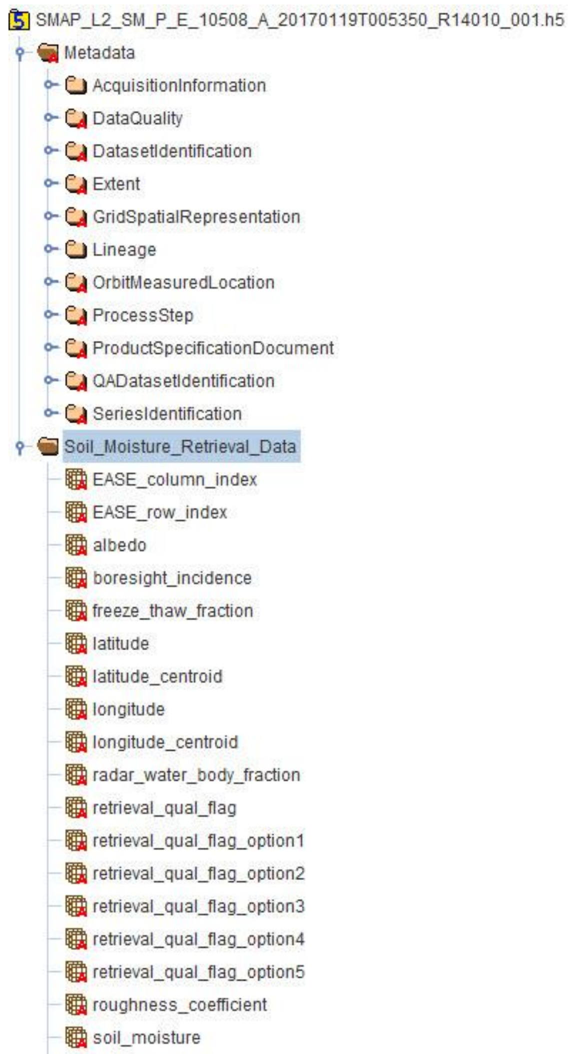

Figure 1. Subset of File Contents. For a complete list of file contents for the SMAP enhanced Level-2 radiometer soil moisture product, refer to the Product Specification Document.

1.2.3 Data Fields

Each file contains the main data groups summarized in this section. For a complete list and description of all data fields within these groups, refer to the Product Specification Document.

1.2.3.1 Soil Moisture Retrieval Data

Includes enhanced soil moisture data, ancillary data, and quality assessment flags.

1.2.4 Metadata Fields

Includes all metadata that describe the full content of each file. For a description of all metadata fields for this product, refer to the Product Specification Document.

1.2.5 File Naming Convention

Files are named according to the following convention, which is described in Table 1:

```
SMAP_L2_SM_P_E_[Orbit#]_[A/D]_yyyymmddThhmmss_RLVvvv_NNN.[ext]
```

For example:

```
SMAP_L2_SM_P_E_10508_A_20170119T005350_R14010_001.h5
```

Table 1. File Naming Conventions

<table>
<tr><th>Variable</th><th>Description</th></tr>
<tr><td>SMAP</td><td>Indicates SMAP mission data</td></tr>
<tr><td>L2_SM_P_E</td><td>Indicates specific product (L2: Level-2; SM: Soil Moisture; P: Passive; E: Enhanced)</td></tr>
<tr><td>[Orbit#]</td><td>5-digit sequential number of the orbit flown by the SMAP spacecraft when data were acquired. Orbit 00000 began at launch. Orbit numbers increment each time the spacecraft flies over the southernmost point in the orbit path.</td></tr>
<tr><td>A/D</td><td>A: Ascending half-orbit pass of the satellite (where satellite moves from South to North, and 6:00 p.m. is the local solar time at the equator)
D: Descending half-orbit pass of the satellite (where satellite moves from North to South, and 6:00 a.m. is the local solar time at the equator)</td></tr>
<tr><td>yyyymmddThhmmss</td><td>Date/time in Universal Coordinated Time (UTC) of the first data element that appears in the product, where:<table><tr><td>yyyymmdd</td><td>4-digit year, 2-digit month, 2-digit day</td></tr><tr><td>T</td><td>Time (delineates the date from the time, i.e. yyyymmddThhmmss)</td></tr><tr><td>hhmmss</td><td>2-digit hour, 2-digit month, 2-digit second</td></tr></table></td></tr>
<tr><td>RLVvvv</td><td>Composite Release ID (CRID), where:<table><tr><td>R</td><td>Release</td></tr><tr><td>L</td><td>Launch Indicator (1: post-launch standard data)</td></tr><tr><td>V</td><td>1-Digit Major CRID Version Number</td></tr><tr><td>vvv</td><td>3-Digit Minor CRID Version Number</td></tr></table>Refer to the SMAP Data Versions page for version information.</td></tr>
<tr><td>NNN</td><td>Number of times the file was generated under the same version for a particular date/time interval (002: 2nd time)</td></tr>
</table>

Variable	Description	
.[ext]	File extensions include:	
	.h5	HDF5 data file
	.qa	Quality Assurance file
	.xml	XML Metadata file

1.3 File Size

Each half-orbit file ranges from approximately 8 to 14 MB.

1.4 Volume

The daily data volume is approximately 300 MB.

1.5 Spatial Coverage

Coverage spans from 180°W to 180°E, and from approximately 85.044°N and 85.044°S for the global EASE-Grid 2.0 projection. The gap in coverage at both the North and South Pole, called a pole hole, has a radius of approximately 400 km. The swath width is approximately 1000 km, enabling nearly global coverage every three days.

1.5.1 Spatial Coverage Map

Figure 2 shows the spatial coverage of the SMAP L-Band Radiometer for one descending half orbit, which comprises one file of this data set.

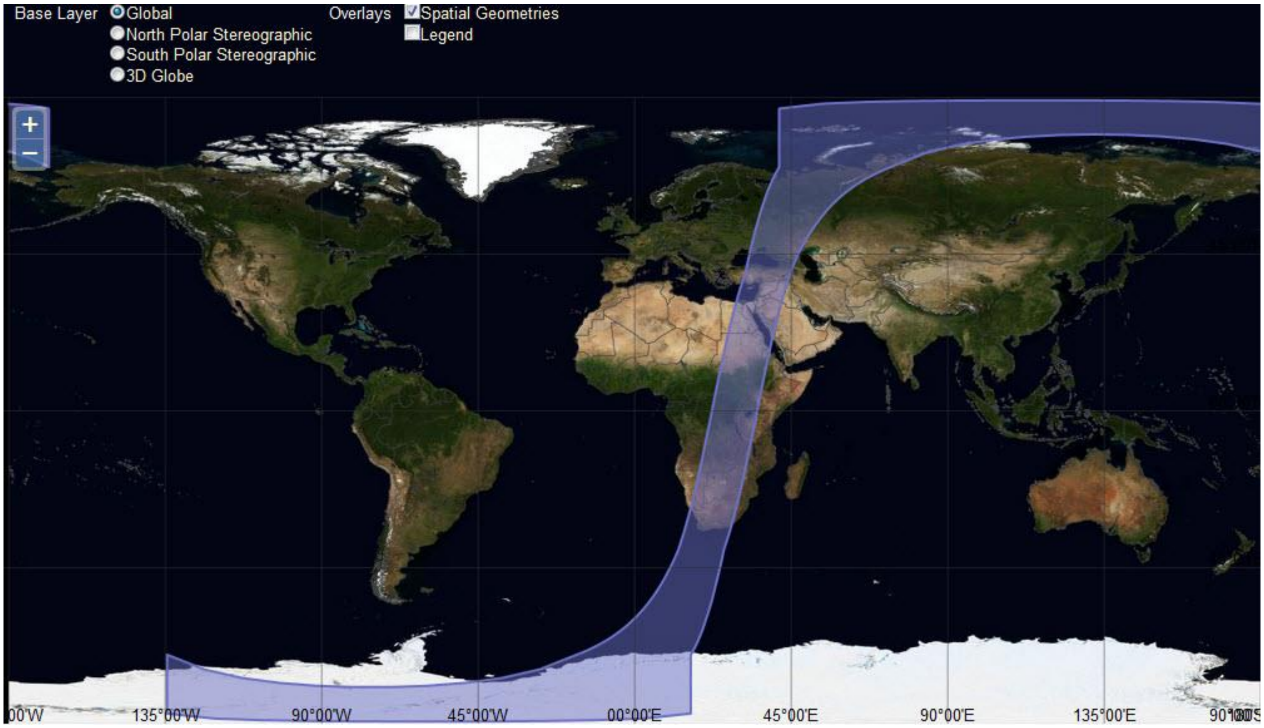

Figure 2. Spatial coverage map displaying one descending half orbit of the SMAP L-Band Radiometer.

1.6 Spatial Resolution

The native spatial resolution of the radiometer footprint is 36 km. Data are then interpolated using the Backus-Gilbert optimal interpolation algorithm into the global cylindrical EASE-Grid 2.0 projection with 9 km spacing.

1.7 Projection and Grid Description

1.7.1 EASE-Grid 2.0

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 9 x 9 km^2 regardless of longitude and latitude.

EASE-Grid 2.0 has a flexible formulation. By adjusting a single scaling parameter, a family of multi-resolution grids that nest within one another can be generated. The nesting can be adjusted so that smaller grid cells can be tessellated to form larger grid cells. Figure 3 shows a schematic of the nesting.

This feature of perfect nesting provides SMAP data products with a convenient common projection for both high-resolution radar observations and low-resolution radiometer observations, as well as for their derived geophysical products. For more on EASE-Grid 2.0, refer to the EASE Grid web page.

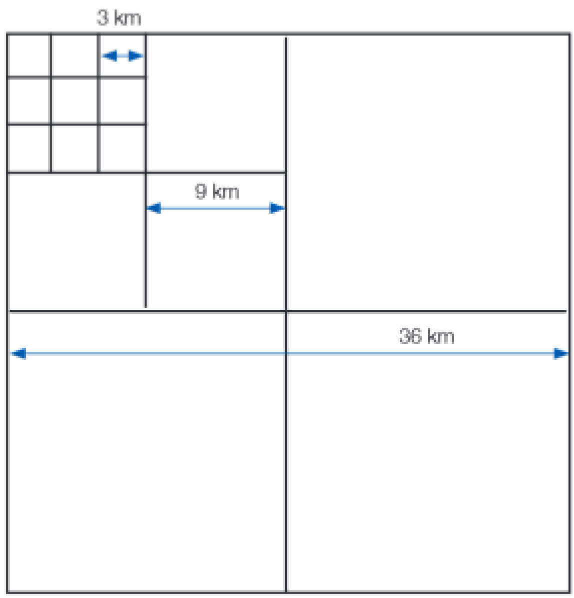

Figure 3. Perfect Nesting in EASE-Grid 2.0

1.8 Temporal Coverage

Coverage spans from 31 March 2015 to 13 August 2019.

1.8.1 Satellite and Processing Events

Due to instrument maneuvers, data downlink anomalies, data quality screening, and other factors, small gaps in the SMAP time series will occur. Details of these events are maintained on two master lists:

SMAP On-Orbit Events List for Instrument Data Users
Master List of Bad and Missing Data

1.8.2 Latencies

FAQ: What are the latencies for SMAP radiometer data sets?

1.9 Temporal Resolution

Each Level-2 half-orbit file spans approximately 49 minutes.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

The microwave portion of the electromagnetic spectrum, which includes wavelengths from a few centimeters to a meter, has long held promise for estimating surface soil moisture remotely. Passive microwave sensors measure the natural thermal emission emanating from the soil surface. The variation in the intensity of this radiation depends on the dielectric properties and temperature of the target medium, which for the near-surface soil layer is a function of the amount of moisture present. Low microwave frequencies, especially at L-band or approximately 1 GHz, offer the following additional advantages:

- The atmosphere is almost completely transparent, providing all-weather sensing
- Transmission of signals from the underlying soil is possible through sparse and moderate vegetation layers (up to at least 5 kg/m2 of vegetation water content)
- Measurement is independent of solar illumination which allows for day and night observations. (O'Neill et al. 2016)

For an in-depth description of the theory of these measurements, refer to Section 2: Passive Remote Sensing of Soil Moisture in the Algorithm Theoretical Basis Document (ATBD) for the SMAP baseline Level-2 soil moisture product, SPL2SMP.

2.2 Acquisition

SMAP enhanced Level-2 radiometer soil moisture data (SPL2SMP_E) are derived from SMAP Enhanced L1C Radiometer Half-Orbit 9 km EASE-Grid Brightness Temperatures, Version 2 (SPL1CTB_E).

2.3 Derivation Techniques and Algorithms

SMAP enhanced Level-2 radiometer soil moisture data (SPL2SMP_E) are derived from SMAP Enhanced L1C Radiometer Half-Orbit 9 km EASE-Grid Brightness Temperatures, Version 2 (SPL1CTB_E). Utilizing a baseline plus four optional soil moisture algorithms discussed below, SMAP brightness temperatures are converted into an estimate of the 0-5 cm surface soil moisture in units of m3/m3.

For information regarding the Backus-Gilbert optimal interpolation algorithm used to enhance these data, refer to the SPL1CTB_E user guide.

The following information has been adapted from O'Neill et al. (2016).

2.4 Derivation Techniques and Algorithms

SMAP enhanced Level-2 radiometer soil moisture data (SPL2SMP_E) are derived from SMAP Enhanced L1C Radiometer Half-Orbit 9 km EASE-Grid Brightness Temperatures, Version 1 (SPL1CTB_E). Utilizing a baseline plus four optional soil moisture algorithms discussed below, SMAP brightness temperatures are converted into an estimate of the 0-5 cm surface soil moisture in units of m3/m3.

For information regarding the Backus-Gilbert optimal interpolation algorithm used to enhance these data, refer to the SPL1CTB_E user guide.

The following information has been adapted from O'Neill et al. (2015).

2.4.1 Algorithm Inputs and Outputs

The main input to the processing algorithm for this product is the SMAP Enhanced L1C Radiometer Half-Orbit 9 km EASE-Grid Brightness Temperatures, Version 1 (SPL1CTB_E) product that contains the time-ordered, geolocated, calibrated SMAP enhanced Level-1B radiometer brightness temperatures (L1B_TB_E) that have been resampled to the fixed 9 km EASE-Grid 2.0. In addition to general geolocation and calibration, the enhanced Level-1B brightness temperature data have also been corrected for atmospheric effects, Faraday rotation, and low-level RFI effects prior to regridding. If the RFI encountered is too large to be corrected, the brightness temperature data are flagged accordingly and no soil moisture retrieval is attempted. Refer to the SPL1CTB_E ATBD for additional details.

In addition to brightness temperature observations, the SPL2SMP_E algorithm also requires ancillary data sets for the soil moisture retrieval. The specific parameters and sources of these and other externally provided ancillary data are listed in Section 6: Ancillary Datasets of the baseline SPL2SMP ATBD. In order for soil moisture to be retrieved accurately, a variety of global static and dynamic ancillary data are required. Static ancillary data are data which do not change during the mission, while dynamic ancillary data require periodic updates in time frames ranging from seasonally to daily. Static data include parameters such as permanent masks (land, water, forest, urban, mountain, etc.), the grid cell average elevation and slope derived from a Digital Elevation Model (DEM), permanent open water fraction, and soils information (primarily sand and clay fraction). Dynamic ancillary data include land cover, surface roughness, precipitation, vegetation parameters, and effective soil temperatures.

Ancillary data are also employed to set flags that help to determine either specific aspects of the processing, such as corrections for open water and frozen ground, or the quality of the retrievals, such as the precipitation flag. Refer to the Data Flags below. All input data to the SPL2SMP_E process are pre-mapped using the 9 km EASE-Grid 2.0 projection and are then aggregated at a spatial extent that is approximately the same as the native resolution (approximately 36 km) of the SMAP radiometer. Other parameters used by the SPL2SMP_E algorithm include a freeze/thaw flag, an open water fraction, and a vegetation index.

The primary contents of output SPL2SMP_E data are the retrieved soil moisture and associated Quality Assessment (QA) flags, as well as the values of the ancillary parameters needed to retrieve the output soil moisture for that grid cell.

2.4.2 Soil Moisture Algorithms

Decades of research by the passive microwave soil moisture community have resulted in a number of viable soil moisture retrieval algorithms that can be used with SMAP brightness temperature data. The European Space Agency (ESA) Soil Moisture and Ocean Salinity Mission (SMOS) mission currently flies an aperture synthesis L-band radiometer which produces brightness temperature data at multiple incidence angles over the same ground location. The baseline SMOS retrieval algorithm is based on the tau-omega model described in the SPL2SMP ATBD, Section 2.1: Physics of the Problem, but utilizes the SMOS multiple-incidence-angle capability to retrieve soil moisture. SMAP retrievals are also based on the tau-omega model, but use the constant-incidence-angle brightness temperature data produced by the SMAP conically-scanning radiometer. Other necessary parameters in the retrieval are obtained as ancillary data.

Prior to implementing the actual soil moisture retrieval, a preliminary step in the processing is to perform a water body correction to the brightness temperature data for cases where a significant percentage of the grid cell contains open water. For more information on the water brightness temperature correction and soil moisture algorithms, refer to Section 4: Retrieval Algorithms of the ATBD for the SPL2SMP product.

The Version 2 SPL2SMP_E product contains soil moisture retrieval fields produced by a baseline and several optional algorithms (Refer to Table 2). Inside an SPL2SMP_E file, the *soil_moisture* field is the one that links to the retrieval result produced by the currently-designated baseline algorithm, the Single Channel Algorithm V-pol (SCA-V). At present, the operational SPL2SMP_E Science Production Software (SPS) produces and stores soil moisture retrieval results from the following five algorithms:

Table 2. Soil Moisture Algorithm Options

Algorithm Options	Corresponding Data Field
Single Channel Algorithm H-pol (SCA-H)	*soil_moisture_option1*
Single Channel Algorithm V-pol (SCA-V) – Current Baseline	*soil_moisture_option2* (Internally linked to the *soil_moisture* field)
Dual Channel Algorithm (DCA)	*soil_moisture_option3*
Microwave Polarization Ratio Algorithm (MPRA)	*soil_moisture_option4*
Extended Dual Channel Algorithm (E-DCA)	*soil_moisture_option5*

Given preliminary results from current SPL2SMP_E Calibration/Validation (Cal/Val) analyses, the SCA-V algorithm seems to deliver slightly better performance than the SCA-H algorithm, which was designated as the pre-launch baseline retrieval algorithm. For this reason, the SCA-V is designated as the current baseline algorithm for the validated release of SPL2SMP_E. However, all five algorithms will be continuously assessed; the choice of the operational algorithm for the validated release of the product will be evaluated on a regular basis as analyses of new observations and Cal/Val data become available, and algorithm parameters are tuned based on a longer SMAP radiometer brightness temperature time series record.

All five algorithms operate on the same zeroth-order microwave emission model commonly known as the tau-omega model. In essence, this model relates brightness temperatures (SMAP L1 observations) to soil moisture (SMAP L2 retrievals) through ancillary information (e.g. soil texture, soil temperature, and vegetation water content) and a soil dielectric model. The algorithms differ in their approaches to solve for soil moisture from the model under different constraints and assumptions. The following sections provide concise descriptions of each algorithm. Further details are provided in O'Neill et al., 2015.

2.4.2.1 Baseline Single Channel Algorithm V-pol (SCA-V)

In the SCA-V, the vertically polarized brightness temperature (TB) observations are converted to emissivity using a surrogate for the physical temperature of the emitting layer. The derived emissivity is corrected for vegetation and surface roughness to obtain the soil emissivity. The Fresnel equation is then used to determine the dielectric constant from the soil emissivity. Finally, a dielectric mixing model is used to solve for the soil moisture given knowledge of the soil texture. Analytically, SCA-V attempts to solve for one unknown variable (soil moisture) from one equation that relates the vertically polarized TB to soil moisture. Vegetation information is provided by a 13-year climatological data base of global Normalized Difference Vegetation Index (NDVI) and a table of parameters based on land cover types.

2.4.2.2 Single Channel Algorithm H-pol (SCA-H)

The SCA-H is similar to SCA-V, in that the horizontally polarized TB observations are converted to emissivity using a surrogate for the physical temperature of the emitting layer. The derived emissivity is corrected for vegetation and surface roughness to obtain the soil emissivity. The Fresnel equation is then used to determine the dielectric constant. Finally, a dielectric mixing model is used to obtain the soil moisture given knowledge of the soil texture. Analytically, SCA-H attempts to solve for one unknown variable (soil moisture) from one equation that relates the horizontally polarized TB to soil moisture. Vegetation information is provided by a 13-year climatological data base of global NDVI and a table of parameters based on land cover.

2.4.2.3 Dual Channel Algorithm (DCA)

In the DCA, both the vertically and horizontally polarized TB observations are used to solve for soil moisture and vegetation optical depth. The algorithm iteratively minimizes a cost function (Φ2) that consists of the sum of squares of the differences between the observed TBs (TBobs) and estimated TBs (TBest):

$$\min \Phi_{DCA}^2 = (T_{B,v}^{obs} - T_{B,v}^{est})^2 + (T_{B,h}^{obs} - T_{B,h}^{est})^2$$

(Equation 1)

In each iteration step, the soil moisture and vegetation opacity are adjusted simultaneously until the cost function attains a minimum in a least square sense. Similar to SCA-V and SCA-H, ancillary information such as effective soil temperature, surface roughness, and vegetation single scattering albedo must be known a priori before the inversion process. DCA permits polarization dependence of coefficients in the forward modeling of TB observations. As currently implemented for SPL2SMP_E (Version 1), the H and V coefficients are set the same.

2.4.2.4 Microwave Polarization Ratio Algorithm (MPRA)

The MPRA is based on the Land Parameter Retrieval Model (Owe 2015) and was first applied to multi-frequency satellites such as AMSR-E. Like DCA, MPRA attempts to solve for soil moisture and vegetation optical depth using the vertically and horizontally polarized TB observations. However, it does so under the assumptions that (1) the soil and canopy temperatures are considered equal, and (2) vegetation transmissivity (γ) and the single-scattering albedo (ω) are the same for both H and V polarizations. When these assumptions are satisfied, it can be shown that the soil moisture and vegetation optical depth can be solved analytically in closed form, resulting in the same solutions as would be obtained iteratively using DCA. Similarly to DCA, ancillary information such as effective soil temperature, surface roughness, and vegetation single scattering albedo must be known a priori before the inversion process.

2.4.2.5 Extended Dual Channel Algorithm (E-DCA)

The E-DCA is a variant of DCA. Like DCA, E-DCA uses both the vertically and horizontally polarized TB observations to solve for soil moisture and vegetation optical depth. In E-DCA, however, the cost function (Φ2) is formulated in a way different from that of DCA. Instead of minimizing the sum of squares of the differences between the observed and estimated TBs as in DCA (see Equation 1), the E-DCA attempts to minimize the sum of squares of the difference between the observed and estimated normalized polarization differences (expressed in natural logarithm) and the difference between the observed and estimated TBs (also expressed in natural logarithm) as follows:

$$\min \Phi^2_{E-DCA} = \left[\log\left(\frac{T^{obs}_{B,v} - T^{obs}_{B,h}}{T^{obs}_{B,v} + T^{obs}_{B,h}}\right) - \log\left(\frac{T^{est}_{B,v} - T^{est}_{B,h}}{T^{est}_{B,v} + T^{est}_{B,h}}\right)\right]^2 + \left[\log\left(T^{obs}_{B,h}\right) - \log\left(T^{est}_{B,h}\right)\right]^2$$

(Equation 2)

In each iteration step, soil moisture and vegetation opacity are adjusted simultaneously until the cost function attains a minimum in a least square sense. It is clear that when both Φ_DCA^2 and Φ_(E-DCA)^2 attain their theoretical minimum value (i.e. zero) in the absence of uncertainties of modeling, observations, and ancillary data, T_(B,v)^obs = T_(B,v)^est and T_(B,h)^obs = T_(B,h)^est, implying that DCA and E-DCA converge to the same solutions. The advantage of E-DCA over DCA, however, is apparent when in reality there is finite uncertainty (e.g., a dry bias associated with the ancillary soil temperature data); this uncertainty will be cancelled from the numerator and denominator in the calculation of the normalized polarization difference in Φ_(E-DCA)^2, leaving such uncertainty affecting only one component of the cost function instead of two components as in Φ_DCA^2. This reduction in the impact of soil temperature uncertainty on soil moisture retrieval should make E-DCA more tolerant of soil temperature uncertainty, resulting in fewer instances of retrieval failure than DCA. At present, there are a few caveats associated with E-DCA: (1) its exact performance is being evaluated in the ongoing Cal/Val activities, and (2) the choice of the horizontally polarized TB in the formulation is subject to further assessment as analyses of new observations and Cal/Val data become available.

2.4.3 Processing Steps

This product is generated by the SMAP Science Data Processing System (SDS) at the Jet Propulsion Laboratory (JPL). To generate this product, the processing software ingests the 6:00 a.m. descending and 6:00 p.m. ascending half-orbit files of the SMAP Enhanced L1C Radiometer Half-Orbit 9 km EASE-Grid Brightness Temperatures, Version 1 (SPL1CTB_E) product. The ingested data are then inspected for retrievability criteria according to input data quality, ancillary data availability, and land cover conditions. When retrievability criteria are met, the software invokes the baseline retrieval algorithm to generate soil moisture retrieval. Only cells that are covered by the actual swath for a given projection are written in the product.

2.4.4 Error Sources

Anthropogenic RFI, principally from ground-based surveillance radars, can contaminate both radar and radiometer measurements at L-band. The SMAP radiometer electronics and algorithms include design features to mitigate the effects of RFI. The SMAP radiometer implements a combination of time and frequency diversity, kurtosis detection, and use of thresholds to detect and, where possible, mitigate RFI.

Level-2 radiometer data can also contain bit errors caused by noise in communication links and memory storage devices. Consultative Committee on Space Data Systems (CCSDS) packets include error-detecting Cyclic Redundancy Checks (CRCs), which are used to flag errors.

More information about error sources is provided in Section 4.6: Algorithm Error Performance of the ATBD. (O'Neill et al. 2016)

2.4.5 Quality Assessment

For in-depth details regarding the quality of these Version 1 data, refer to the Validated Assessment Report.

2.4.5.1 Quality Overview

Each HDF5 file contains metadata with Quality Assessment (QA) metadata flags that are set by the Science Data Processing System (SDS) at the JPL prior to delivery to the National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC). A separate metadata file with an .xml file extension is also delivered to NSIDC with the HDF5 file; it contains the same information as the HDF5 file-level metadata.

A separate QA file with a .qa file extension is also associated with the HDF5 file; it contains useful statistics such as the percentage of elements having various quality conditions. If a product does not fail QA, it is ready to be used for higher-level processing, browse generation, active science QA, archive, and distribution. If a product fails QA, it is never delivered to NSIDC DAAC.

The information in the following sections has been adapted from O'Neill et al. (2015).

2.4.5.2 6:00 p.m. Ascending Half Orbits

Data from both 6:00 a.m. descending and 6:00 p.m. ascending half-orbit passes are used as input for soil moisture derivation in this Version 4 Validated product. However, the radiometer soil moisture algorithm assumes that the air, vegetation, and near-surface soil are in thermal equilibrium in the early morning hours; thus, retrievals from 6:00 p.m. ascending half-orbit passes show a slight degradation in quality. Nonetheless, ubRMSE (unbiased root mean square error) and correlation of the p.m. and a.m. retrievals are relatively close.

2.4.5.3 Data Flags

Bit flags generated from input SMAP data and ancillary data are also employed to help determine the quality of the retrievals. Ancillary data help determine either specific aspects of the processing, such as corrections for transient water, or the quality of the retrievals, such as the precipitation flag. These flags provide information as to whether the ground is frozen, covered with snow, flooded, or whether it is actively precipitating at the time of the satellite overpass. Other flags will indicate whether masks for steeply sloped topography, or for urban, heavily forested, or permanent snow/ice areas are in effect.

The flags described below, for example, are used in the surface_flag. Refer to Table 4 of the Product Specification Document for more details. Unless otherwise stated, all areal fractions defined below refer to 33 x 33 km2 inversion domain.

2.4.5.4 Open Water Flag

Open water fraction can be determined from SMAP high-resolution radar and/or a priori information on permanent open freshwater from the Moderate Resolution Imaging Spectroradiometer (MODIS) MOD44W database. The SPL2SMP_E Version 1 product uses the MOD44W database due to the maturity of the SMAP radar open-water algorithm and availability of radar measurements, and are reported in Bit 0 and 1 in the surface_flag of the SPL2SMP_E product. This information serves as a flag to affect soil moisture retrieval processing in the following ways:

- If areal water fraction is 0.00–0.05, then do not flag, but retrieve soil moisture.
- If areal water fraction is 0.05–0.50, then flag and retrieve soil moisture.
- If areal water fraction is 0.50–1.00, then flag, but do not retrieve soil moisture.

2.4.5.5 Precipitation Flag

The SMAP precipitation flag is set based on either forecasts of precipitation or using data from the Global Precipitation Mission (GPM). It is a binary precipitation/no precipitation flag which indicates the presence or absence of precipitation within a 33 km inversion domain at the time of the SMAP overpass. The presence of liquid in precipitation incident on the ground at the time of the SMAP overpass can adversely bias the retrieved soil moisture due to its large impact on SMAP brightness temperatures, as precipitation in the atmosphere is part of the atmospheric correction done in Level-1B brightness temperature processing. Unlike other flags, soil moisture retrieval will always be attempted even if precipitation is flagged. However, this flag serves as a warning to the user to view the retrieved soil moisture with some skepticism if precipitation is present.

- If precipitation is 0–1 mm/hr, then do not flag, but retrieve soil moisture.
- If precipitation is 1–25 mm/hr, then flag and retrieve soil moisture.
- If precipitation is above 25 mm/hr, then flag, but do not retrieve soil moisture.

2.4.5.6 Snow Flag

Although the SMAP L-Band Radiometer can theoretically see through dry snow with its low dielectric to the soil underneath a snowpack, the snow flag is set based on the snow fraction as reported in the National Oceanic and Atmospheric Administration (NOAA) Interactive Multisensor Snow and Ice Mapping System (IMS) database. The snow flag affects soil moisture retrieval processing in the following ways:

- If snow areal fraction is 0.00–0.10, then do not flag, but retrieve soil moisture.
- If snow areal fraction is 0.10–0.90, then flag and retrieve soil moisture.
- If snow areal fraction is above 0.90, then flag, but do not retrieve soil moisture.

2.4.5.7 Frozen Ground Flag

The frozen ground flag is set from either 1) the flag passed through from the SMAP radiometer freeze/thaw algorithm, or 2) from modeled surface temperature information (TSURF) from the Global Modeling and Assimilation Office (GMAO). These sources for the frozen ground flag are contained in the SPL2SMP_E product and are reflected in bits 7 and 8 of the surface_flag (bit 7: SMAP radiometer-derived freeze/thaw state; bit 8: GMAO TSURF). For this SPL2SMP_E Version 1 product, GMAO TSURF (bit 8) is used to determine frozen ground condition.

The frozen soil flag affects soil moisture retrieval processing in the following ways:

- If frozen ground areal fraction is 0.00–0.10, then do not flag, but retrieve soil moisture.
- If frozen ground areal fraction is 0.10–0.90, then flag and retrieve soil moisture.
- If frozen ground areal fraction is above 0.90, then flag, but do not retrieve soil moisture.

Note: SMAP radiometer freeze/thaw flags are presently validated only for all land regions north of 45°N latitude. While the SPL2SMP_E product contains global SMAP freeze/thaw flags, uncertainty in the flags is higher south of 45°N latitude due to small differences in the SMAP radiometer-derived reference freeze and thaw states upon which the freeze/thaw algorithm is based. Further information is available in the SMAP Level-3 Freeze/Thaw (SPL3FTP) Validated Assessment Report.

2.4.5.8 Urban Area Flag

Since the brightness temperature of man-made, impervious, and urban areas cannot be estimated theoretically, the presence of urban areas in the 36 km Level-2 soil moisture grid cell cannot be corrected for during soil moisture retrieval. Thus, the presence of even a small amount of urban area in the radiometer footprint is likely to adversely bias the retrieved soil moisture. The SMAP urban flag is set based on the Columbia University Global Rural-Urban Mapping Project (GRUMP) data set (O'Neill et al. 2015). The urban fraction affects soil moisture retrieval processing in the following ways:

- If urban areal fraction is 0.00–0.25, then do not flag, but retrieve soil moisture.
- If urban areal fraction is above 0.25, then flag and retrieve soil moisture.

2.4.5.9 Mountainous Area Flag

Large and highly variable slopes present in the radiometer footprint will adversely affect the retrieved soil moisture. The SMAP mountainous area flag is derived from a combination of high elevation information from the DEM coupled with a statistical threshold based on the slope and slope variability within each 36 km grid cell. Most likely, soil moisture retrieval will still be attempted in most areas flagged as mountainous.

- If slope standard deviation is 0.0–3.0°, then do not flag, but retrieve soil moisture.
- If slope standard deviation is 3.0°–6.0°, then flag and retrieve soil moisture.
- If slope standard deviation is above 6.0°, then flag, but do not retrieve soil moisture.

For in-depth details on all data flags, refer to the Product Specification Document.

2.4.6 Instrumentation

2.4.6.1 Description

For a detailed description of the SMAP instrument, visit the SMAP Instrument page at the Jet Propulsion Laboratory (JPL) SMAP website.

3 SOFTWARE AND TOOLS

For tools that work with SMAP data, see the Tools Web page.

4 VERSION HISTORY

4.1 Document Creation Date

December 2016

4.2 Document Revision Date

June 2018

5 RELATED DATA SETS

SMAP Data at NSIDC | Overview

SMAP Radar Data at the ASF DAAC

6 RELATED WEBSITES

SMAP at NASA JPL

7 CONTACTS AND ACKNOWLEDGMENTS

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9 DOCUMENT INFORMATION

9.1 Publication Date

3 January 2019

9.2 Date Last Updated

4 June 2019