National Snow and Ice Data Center

Data Set ID: SPL3SMP_E

SMAP Enhanced L3 Radiometer Global Daily 9 km EASE-Grid Soil Moisture, Version 2

This enhanced Level-3 (L3) soil moisture product provides a composite of daily estimates of global land surface conditions retrieved by the Soil Moisture Active Passive (SMAP) radiometer. This product is a daily composite of SMAP Level-2 (L2) soil moisture which is derived from SMAP Level-1C (L1C) interpolated brightness temperatures. Backus-Gilbert optimal interpolation techniques are used to extract information from SMAP antenna temperatures and convert them to brightness temperatures, which are posted to the 9 km Equal-Area Scalable Earth Grid, Version 2.0 (EASE-Grid 2.0) in a global cylindrical projection.

Version Summary:

Changes to this version include:

- Level-1B water-corrected brightness temperatures are used in passive soil moisture retrieval. This procedure corrects for anomalous soil moisture values seen near coastlines in the previous version and should result in less rejected data due to waterbody contamination. Five new data fields accommodate this correction: grid_surface_status, surface_water_fraction_mb_h, surface_water_fraction_mb_v, tb_h_uncorrected, and tb_v_uncorrected.
- Improved depth correction for effective soil temperature used in passive soil moisture retrieval; new results are captured in the surface_temperature data field. This correction reduces the dry bias seen when comparing SMAP data to in situ data from the core validation sites.
- Frozen ground flag updated to reflect improved freeze/thaw detection algorithm, providing better accuracy; new results are captured in bit 7 of surface_flag.

Overview

Parameter(s):	Microwave > Brightness Temperature Soils > Soil Moisture/Water Content > Soil Moisture
Spatial Coverage:	N: 85.044, S: -85.044, E: 180, W: -180
Spatial Resolution:	9 km x 9 km
Temporal Coverage:	31 March 2015 to present
Temporal Resolution:	1 day
Data Format(s):	HDF5
Platform(s)	SMAP Observatory
Sensor(s):	SMAP L-BAND RADIOMETER
Version:	V2
Data Contributor(s):	O'Neill, P. E., S. Chan, E. G. Njoku, T. Jackson, and R. Bindlish.
Metadata XML:	View Metadata Record

Citing These Data

Data Citation

As a condition of using these data, you must cite the use of this data set using the following citation. For more information, see our Use and Copyright Web page.

O'Neill, P. E., S. Chan, E. G. Njoku, T. Jackson, and R. Bindlish. 2018. *SMAP Enhanced L3 Radiometer Global Daily 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. doi: https://doi.org/10.5067/RFKIZ5QY5ABN. [Date Accessed].

Documentation

Detailed Data Description

Parameter Description

Surface soil moisture (0-5 cm) in m^3/m^3 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 Data Fields document for details on all parameters.

Format

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

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:

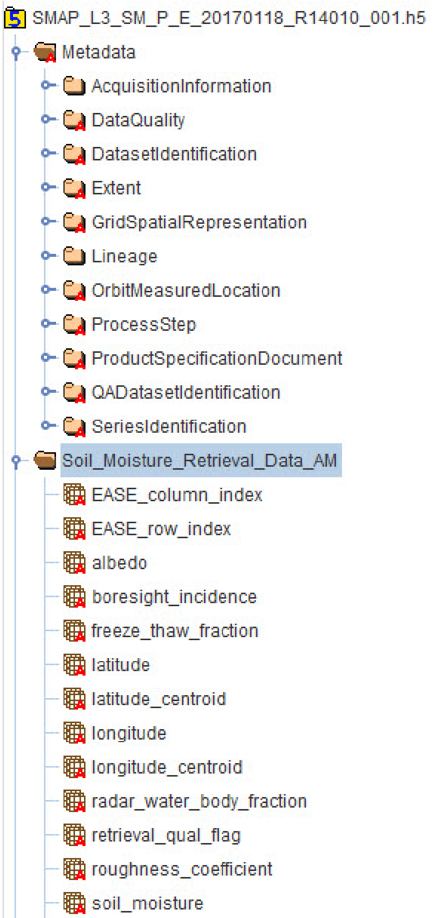

Figure 1. Subset of File Contents
For a complete list of file contents for the SMAP enhanced Level-3 radiometer soil moisture product, refer to the Data Fields page.

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 Data Fields document.

Soil Moisture Retrieval Data AM

Includes soil moisture data, ancillary data, and quality assessment flags for each descending half-orbit pass of the satellite [where the satellite moves from North to South and 6:00 a.m. is the Local Solar Time (LST) at the equator].

Soil Moisture Retrieval Data PM

Includes soil moisture data, ancillary data, and quality assessment flags for each ascending half-orbit pass of the satellite (where the satellite moves from South to North and 6:00 p.m. is the LST at the equator.

Corrected brightness temperatures are also provided for each AM and PM group. For these brightness temperatures (such as *tb_3_corrected*), an additional procedure has been applied to correct for anomalous water and land values. Further details are provided in the Water/Land Contamination Correction section of the SPL2SMP user guide.

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 Metadata Fields document.

File Naming Convention

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

`SMAP_L3_SM_P_E_yyyymmdd_RLVvvv_NNN.[ext]`

For example:

`SMAP_L3_SM_P_E_20170117_R14010_001.h5`

Where:

Table 1. File Naming Conventions

<table>
<tr><th>Variable</th><th>Description</th></tr>
<tr><td><code>SMAP</code></td><td>Indicates SMAP mission data</td></tr>
<tr><td><code>L3_SM_P_E</code></td><td>Indicates specific product (<code>L3</code>: Level-3; <code>SM</code>: Soil Moisture; <code>P</code>: Passive; <code>E</code>: Enhanced)</td></tr>
<tr><td><code>yyyymmdd</code></td><td>4-digit year, 2-digit month, 2-digit day of the first data element that appears in the product.</td></tr>
<tr><td><code>RLVvvv</code></td><td>Composite Release ID (CRID), where:
<table>
<tr><td><code>R</code></td><td>Release</td></tr>
<tr><td><code>L</code></td><td>Launch Indicator (<code>1</code>: post-launch standard data)</td></tr>
<tr><td><code>V</code></td><td>1-Digit Major CRID Version Number</td></tr>
<tr><td><code>vvv</code></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><code>NNN</code></td><td>Product Counter: Number of times the file was generated under the same version for a particular date/time interval (<code>002</code>: second time)</td></tr>
<tr><td><code>.[ext]</code></td><td>File extensions include:
<table>
<tr><td><code>.h5</code></td><td>HDF5 data file</td></tr>
<tr><td><code>.qa</code></td><td>Quality Assurance file</td></tr>
<tr><td><code>.xml</code></td><td>XML Metadata file</td></tr>
</table></td></tr>
</table>

File Size

Each file is approximately 271 MB.

Volume

The daily data volume is approximately 271 MB.

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 two to three days.

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.

Projection and Grid Description

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. Using this projection, global data arrays have dimensions of 1624 rows and 3856 columns.

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 2 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 2.0 Format Description.

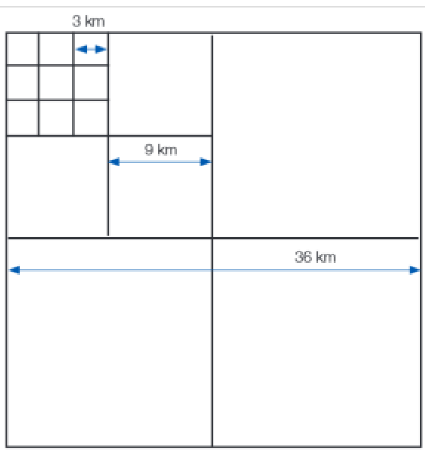

Figure 2. Perfect Nesting in EASE-Grid 2.0

Temporal Coverage

Coverage spans from 31 March 2015 to present.

Temporal Coverage Gaps

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

Latencies

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

Temporal Resolution

Each enhanced Level-3 file is a daily composite of half-orbit files/swaths.

Data Access and Tools

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

Data Acquisition and Processing

This section has been adapted from O'Neill et al. (2016).

Sensor or Instrument Description

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

Data Source

SMAP enhanced Level-3 radiometer soil moisture data (SPL3SMP_E) are composited from SMAP Enhanced L2 Radiometer Half-Orbit 9 km EASE-Grid Soil Moisture, Version 2 (SPL2SMP_E).

Theory of Measurements

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/m^2 of vegetation water content)
- Measurement is independent of solar illumination which allows for day and night observations

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 Level-2 soil moisture product (SPL2SMP), O'Neill et al. 2016.

Derivation Techniques and Algorithms

The SMAP enhanced Level-3 radiometer soil moisture product (SPL3SMP_E) is a daily composite of the SMAP Enhanced L2 Radiometer Half-Orbit 9 km EASE-Grid Soil Moisture, Version 2 (SPL2SMP_E). The derivation of soil moisture from SMAP brightness temperatures occurs in the Level-2 processing.

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

Refer to the Derivation Techniques section in the SPL2SMP_E user guide for details on algorithms and ancillary data.

Processing Steps

The SPL3SMP_E product is a daily global product. To generate the product, individual SPL2SMP_E half-orbit files acquired over one day are composited to produce a daily multi-orbit global map of retrieved soil moisture.

The SPL2SMP_E swaths overlap poleward of approximately +/- 65° latitude. Where overlap occurs, three options were considered for compositing multiple data points at a given grid cell:

1. Use the most recent (or last-in) data point
2. Take the average of all data points within the grid cell
3. Choose the data points observed closest to 6:00 a.m. Local Solar Time (LST) for observations derived from SMAP descending passes and closest to 6:00 p.m. LST for observations derived from SMAP descending passes

The current approach for the SPL3SMP_E product is to use the nearest 6:00 a.m. LST and nearest 6:00 p.m. LST criteria to perform Level-3 compositing separately for descending and ascending passes, respectively. According to these criteria, for a given grid cell, an L2 data point acquired closest to 6:00 a.m. LST or closest to 6:00 p.m. LST will make its way to the final enhanced Level-3 file; other late-coming L2 data points falling into the same grid cell will be ignored. For a given L2 half-orbit granule whose time stamp (yyyymmdd***T***hhmmss) is expressed in UTC, only the hhmmss part is converted into local solar time. (O'Neill et al. 2016)

Error Sources

Anthropogenic Radio Frequency Interference (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 T4 thresholds to detect and, where possible, mitigate RFI.

Radiometer enhanced L3 data can contain bit errors caused by noise in communication links and memory storage devices. The CCSDS packets include error-detecting Cyclic Redundancy Checks (CRCs), which the L1A processor uses 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.

Quality Assessment

For in-depth details regarding the quality of these data, refer to the following report:

Validated Assessment Report

Quality Overview

SMAP products provide multiple means to assess quality. Each product contains bit flags, uncertainty measures, and file-level metadata that provide quality information. For information regarding the specific bit flags, uncertainty measures, and file-level metadata contained in this product, refer to the Data Fields and Metadata Fields documents.

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 NSIDC. 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 file-level metadata.

A separate QA file with a .qa file extension is also associated with each data file. QA files are ASCII text files that contain statistical information in order to help users better assess the quality of the associated data file.

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.

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 (e.g. precipitation flag). These flags will provide information as to whether the ground is frozen, snow-covered, or 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.

For a description of the data flag types and methods of flagging, refer to the Data Flags section in the SPL2SMP_E user guide. All flags in SPL2SMP_E are carried over into the SPL3SMP_E product.

References and Related Publications

References

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Jet Propulsion Laboratory (JPL). "SMAP Instrument." JPL SMAP Soil Moisture Active Passive. https://smap.jpl.nasa.gov/observatory/instrument/ [20 August 2015].

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Owe, M., De Jeu, R. A. M., and Walker, J. P. 2015. A Methodology for Surface Soil Moisture and Vegetation Optical Depth Retrieval Using the Microwave Polarization Difference Index. *IEEE Transactions on Geoscience and Remote Sensing*, 39(8):1643–1654, 2001.

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Poe, G. A. 1990. Optimum Interpolation of Imaging Microwave Radiometer Data. *IEEE Transactions on Geoscience and Remote Sensing* 28(5):800-810.

Technical References

For additional references, such as ATBDs, refer to the Technical References tab at the top of this user guide.

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Document Information

Document Creation Date

December 2016

Document Revision Date

June 2018

See Also

Support

FAQ

What are the latencies for SMAP radiometer data sets?
The following table describes both the required and actual latencies for the different SMAP radiometer data sets. Latency is defined as the time (# days, hh:mm:ss) from data acquisition to product generation. Short name Title Latency Required Actual (mean1) SPL1AP SMAP L1A... read more

What data subsetting, reformatting, and reprojection services are available for SMAP data?
The following table describes the data subsetting, reformatting, and reprojection services that are currently available for SMAP data via the NASA Earthdata Search tool. Short name Title Subsetting... read more

Why don't the SMAP enhanced soil moisture products include landcover class?
While the standard SMAP Level-2 and -3 radiometer soil moisture products* contain landcover_class and landcover_class_fraction in the data files, the enhanced soil moisture products** do not. This is because the landcover class ancillary data are not available at the 9 km grid posting that the... read more

How are the enhanced SMAP radiometer products generated and what are the benefits of using these products?
There is considerable overlap of the SMAP radiometer footprints, or Instantaneous Fields of View (IFOVs), which are defined by the contours where the sensitivity of the antenna has fallen by 3db from its maximum. The IFOVs are spaced about 11 km apart in the along scan direction with scan lines... read more

How To

How do I programmatically request data services such as subsetting, reformatting, and reprojection using an API?
The subsetting, reformatting, and reprojection services provided by NSIDC through NASA Earthdata Search can also be accessed programmatically as a synchronous REST interface. This programmatic access is provided via an HTTPS URL containing a series of... read more

How to import and geolocate SMAP Level-3 and Level-4 data in ENVI
The following are instructions on how to import and geolocate SMAP Level-3 Radiometer Soil Moisture HDF5 data in ENVI. Testing notes Software: ENVI Software version: 5.3 Platform: Windows 7 Data set: SMAP L3 Radiometer Global Daily 36 km EASE-Grid Soil... read more

How do I search, order, and customize SMAP data using Earthdata Search?
This video tutorial and attached PDF document provide step-by-step instructions on how to search, order, and customize SMAP data using Earthdata Search (https://search.earthdata.nasa.... read more

How do I interpret the surface and quality flag information in the Level-2 and -3 passive soil moisture products?
SMAP data files contain rich quality information that can be useful for many data users. The retrieval quality flag and surface flag bit values and interpretations are documented in the respective product Data Fields pages: Level-2 soil moisture product (SPL2SMP)... read more

How to Import SMAP HDF Data Into ArcGIS
Selected SMAP L4, Version 4 HDF data (SPL4SMAU, SPL4SMGP, & SPL4SMLM) can be added to ArcGIS with a simple drag/drop or using the 'Add Data' function. These data can be imported and visualized but not geolocated. In order to import, project, and scale these data and other SMAP L3 and L4 HDF... read more

How do I access data using OPeNDAP?
Data can be programmatically accessed using NSIDC's OPeNDAP Hyrax server, allowing you to reformat and subset data based on parameter and array index. For more information on OPeNDAP, including supported data sets and known issues, please see our OPeNDAP documentation: ... read more

How to extract point and area samples of SMAP data using AppEEARS
This step-by-step tutorial demonstrates how to access NASA SMAP data using the Application for Extracting and Exploring Analysis Ready Samples (AppEEARS). AppEEARS allows users to obtain and display point and area data using spatial, temporal, and layer subsets. SMAP data from NSIDC that are... read more

Access complete Knowledge Base

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