SMAP L3 Radiometer Global Daily 36 km EASE-Grid Soil Moisture

This 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) passive microwave radiometer. Ancillary data include soil temperature, vegetation water content, and vegetation opacity and albedo. Input SMAP L-band brightness temperatures are resampled to a global, cylindrical 36 km Equal-Area Scalable Earth Grid, Version 2.0 (EASE-Grid 2.0).

Note: These data are Beta-release quality, meaning that they have not undergone full validation and may still contain significant errors.

Overview

Platform	SMAP Observatory
Sensors	SMAP L-Band Radiometer
Spatial Coverage	Global, between 85.044°N and 85.044°S
Spatial Resolution	36 km
Temporal Coverage	10 September 2015– present **Note:** Data will be made available as they are processed; see the Notice Regarding Data Availability.
Temporal Resolution	Daily
Parameters	Albedo Brightness Temperature Soil Moisture Surface Roughness Vegetation Water Content
Data Format	Hierarchical Data Format, Version 5 (HDF5)
Metadata Access	View Metadata Record
Version	V1. See the SMAP Data Versions page for version information. **Maturity State:** Beta **Note:** These data are Beta-release quality, meaning that they have not undergone full validation and may still contain significant errors.
Error Sources	Radio Frequency Interference (RFI) Radiometric Noise Calibration and Gridding Errors
Get Data	FTP HTTPS Reverb | ECHO Worldview Subscription

Table of Contents

Citing These Data

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., S. Chan, E. Njoku, and T. Jackson. 2015. *SMAP L3 Radiometer Global Daily 36 km EASE-Grid Soil Moisture.* Version 1. [indicate subset used]. Boulder, Colorado USA: NASA National Snow and Ice Data Center Distributed Active Archive Center. http://dx.doi.org/10.5067/NTZW5L0XYP38.

1. Detailed Data Description

Note: These data are Beta-release quality, meaning that they have not undergone full validation and may still contain significant errors.

Format

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

File Structure

As shown in Figure 1, each HDF5 file is organized into two main groups: `Metadata` and `Soil_Moisture_Retrieval_Data`. Within those groups are additional groups and/or data sets. For example, the `Metadata` group contains the `AquisitionInformation` group, and the `Soil_Moisture_Retrieval_Data` group contains the `EASE_column_index` data set.

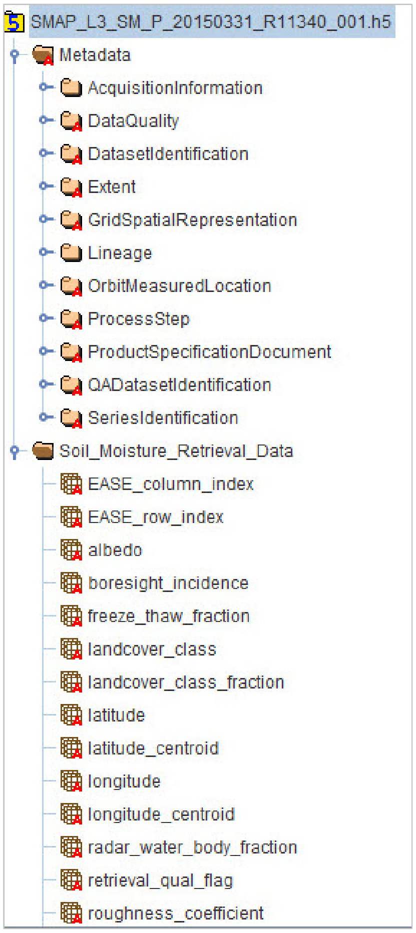

Figure 1. Partial Sample of the HDF5 File Structure

Data Fields Overview

Each Level-3 radiometer soil moisture file contains the following:

Metadata

Includes all metadata that describe the full content of each granule. For a description of all metadata fields for this product, refer to the Metadata Fields document.

Soil Moisture Retrieval Data

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

Data Fields

For a complete list and description of all data fields, refer to the Data Fields document.

File Naming Convention

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

`SMAP_L3_SM_P_yyyymmdd_RLVvvv_NNN.[ext]`

For example:

`SMAP_L3_SM_P_20150705_R11650_001.h5`

Where:

Table 1. File Naming Conventions

Variable	Description
SMAP	Indicates SMAP mission data
L3_SM_P	Indicates specific product (L3: Level-3; SM: Soil Moisture; P: Passive)
yyyymmdd	4-digit year, 2-digit month, 2-digit day of the first data element that appears in the product.
RLVvvv	Composite Release ID, where: R – Release L – Launch Indicator (1: post-launch standard data) V – 1-Digit Major Version Number vvv – 3-Digit Minor Version Number **Example:** R14001 indicates a standard data product with a version of 4.001.
NNN	Product Counter: Number of times the file was generated under the same version for a particular date/time interval (002: second time)
.[ext]	File extensions include: .h5 – HDF5 data file .qa – Quality Assurance file .xml – XML Metadata file

File Size

Each file is approximately 10.24 MB using HDF compression.

Spatial Coverage

Coverage spans from 180°W to 180°E, and from approximately 85.044°N and 85.044°S. 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 1000 km, enabling nearly global coverage every three days.

Spatial Resolution

The native spatial resolution of the radiometer footprint is approximately 40 km. Data are then gridded using the 36 km EASE-Grid 2.0 global projection.

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 36 x 36 km^2 regardless of longitude and latitude. Using this projection, all global data arrays have dimensions of 406 rows and 964 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.

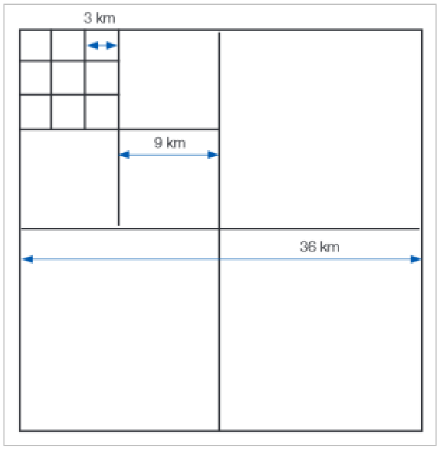

Figure 2. Perfect Nesting in EASE-Grid 2.0

Temporal Coverage

Data were collected from 10 September 2015 to present.

14 September 2015 — Notice Regarding Data Availability
As of 09 September 2015, the SMAP Science Data System (SDS) began forward processing of SMAP Version 1 Beta radiometer data, which will be made available at the National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC) within fifty hours of satellite observation. Reprocessing of the data from 31 March 2015 to 9 September 2015 to Version 1 will begin at the end of October 2015. At that time we will send an announcement.

Temporal Resolution

Data are collected daily.

Parameter Description

Surface soil moisture (0-5 cm) in cm^3/cm^3 derived from the SMAP radiometer as output on a fixed 36-km EASE-Grid 2.0.

Refer to the Data Fields document for details on all parameters.

2. Data Access and Tools

Get Data

Data are available via FTP and HTTPS.

Data are also available through the services listed in Table 2.

Table 2. Data Access Services

Service	Description
Reverb | ECHO	NASA search and order tool for subsetting, reprojecting, and reformatting data.
Worldview	NASA visualization tool for browsing full-resolution imagery and downloading the underlying data.
Subscription	Subscribe to have new data automatically sent when the data become available.

Software and Tools

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

3. Data Acquisition and Processing

This section has been adapted from O'Neill et al. (2012).

Sensor or Instrument Description

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

Data Source

SMAP Level-3 radiometer soil moisture data (SPL3SMP) are derived from SMAP L2 Radiometer Half-Orbit 36 km EASE-Grid Soil Moisture, Version 1.

Note: These data are beta release quality, meaning that they have not undergone full validation and may still contain significant errors.

Theory of Measurements

The microwave portion of the electromagnetic spectrum, which includes wavelengths from a few centimeters to a meter, has long held the most 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, 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), and
- measurement is independent of solar illumination which allows for day and night observations. (O'Neill et al. 2015)

For an in-depth description of the theory of these measurements, refer to Passive Remote Sensing of Soil Moisture in the Algorithm Theoretical Basis Document (ATBD) for this product.

Derivation Techniques and Algorithms

The SMAP Level-3 radiometer soil moisture is a daily gridded composite of the SMAP L2 Radiometer Half-Orbit 36 km EASE-Grid Soil Moisture, Version 1 (SPL2SMP). The derivation of soil moisture from SMAP brightness temperatures occurs in the Level-2 processing.

Please refer to the Derivation Techniques section in the SPL2SMP user guide for details on algorithms and ancillary data.

Processing Steps

The SPL3SMP product is a daily global product. To generate the product, individual SPL2SMP half-orbit granules acquired over one day are composited to produce a daily multi-orbit global map of retrieved soil moisture.

The SPL2SMP swaths overlap poleward of approximately +/- 65° latitude. Where overlap occurs, three options are 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 point observed closest to 6:00 a.m. local solar time (LST)

The current approach for the SPL3SMP product is to use the nearest 6:00 a.m. LST criterion to perform Level-3 compositing. According to this criterion, for a given grid cell, an L2 data point acquired closest to 6:00 a.m. local solar time will make its way to the final Level-3 granule; other late-coming L2 data points falling into the same grid cell will be ignored. For a given granule whose time stamp (yyyy-mm-ddThh:mm:ss) is expressed in UTC, only the hh:mm:ss part is converted into local solar time. For example:

UTC Time Stamp	Longitude	Local Solar Time
2011-05-01T23:19:59	60E	23:19:59 + (60/15) hrs = 03:19:59

The local solar time 03:19:59 is then compared with 06:00:00 in Level-3 processing for 2011-05-01 to determine if the swath is acquired closest to 6:00 a.m. local solar time. If so, that data point (and only that data point) will go to the final Level-3 granule. Under this convention, an L3 composite for 2011-05-01 has all Level-2 granules acquired within 24 hours of 2011-05-01 UTC and Level-2 granules appearing at 2011-05-02 6:00 a.m. local solar time at the equator. Note that this is also the conventional way to produce Level-3 products in similar missions and is convenient to users interested in global applications. (O'Neill et al. 2012).

Note: These data are beta release quality, meaning that they have not undergone full validation and may still contain significant errors.

Error Sources

Anthropogenic Radio Frequency Interference (RFI), principally from ground-based surveillance radars, can contaminate both radar and radiometer measurements at L-band. Early measurements and results from ESA's Soil Moisture and Ocean Salinity (SMOS) mission indicate that in some regions RFI is present and detectable. The SMAP radar and radiometer electronics and algorithms include design features to mitigate the effects of RFI. The SMAP radar utilizes selective filters and an adjustable carrier frequency to tune to predetermined RFI-free portions of the spectrum while on orbit. 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 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. 2015)

Quality Assessment

Though SMAP Level-3 radiometer data are available from 10 September 2015, these Version 1 Beta data employ preliminary algorithms that are still being validated and are thus subject to uncertainties. Data users who wish to use data with the highest quality possible should use data beginning with half-orbit 1216 A, which includes data acquired on 24 April 2015. For in-depth details regarding the quality of these Version 1 Beta data, refer to the Beta Calibration Report.

Quality Overview

This section has been adapted from O'Neill et al. (2012). 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. 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 file/granule fails QA, the SDS does not send the granule to NSIDC until it is reprocessed. Level-3 products that fail QA are never delivered to NSIDC. Only a QA file is produced when there are no L2A brightness temperature data that qualify for retrieval.

Data Flags

Ancillary data will sometimes also be employed to 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 user guide.

4. References and Related Publications

Brodzik, M. J., B. Billingsley, T. Haran, B. Raup, and M. H. Savoie. 2012. EASE-Grid 2.0: Incremental but significant improvements for Earth-gridded data sets. *ISPRS Int. J. Geo-Inf*. 1(1):32-45. doi:10.3390/ijgi1010032. http://www.mdpi.com/2220-9964/1/1/32/.

Brodzik, M. J., B. Billingsley, T. Haran, B. Raup, and M. H. Savoie. 2014. Correction: Brodzik, M. J. et al. EASE-Grid 2.0: Incremental but significant improvements for Earth-gridded data sets. *ISPRS Int. J. Geo-Inf 2012*. 1(1):32-45 *ISPRS Int. J. Geo-Inf.* 3(3):1154-1156. doi:10.3390/ijgi3031154. http://www.mdpi.com/2220-9964/3/3/1154/.

Entekhabi, Dara et al. 2014. SMAP handbook–soil moisture active passive: Mapping soil moisture and freeze/thaw from space. SMAP Project, JPL CL#14-2285, Jet Propulsion Laboratory, Pasadena, CA.

O'Neill, P. E., E. G. Njoku, T. J. Jackson, S. Chan, and R. Bindlish. 2015. SMAP Algorithm Theoretical Basis Document Level 2 & 3 Soil Moisture (Passive) Data Products. SMAP Project, JPL D-66480, Jet Propulsion Laboratory, Pasadena, CA. (https://nsidc.org/sites/nsidc.org/files/files/L2_SM_P_ATBD_v7_Sep2015-po-en(1).pdf, 6 MB)

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5. Contacts and Acknowledgments

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6. Document Information

Acronyms and Abbreviations

Table 3 lists the list of acronyms and abbreviations used in this document.

Table 3. Acronyms and Abbreviations

Acronym	Description
ATBD	Algorithm Theoretical Basis Document
CRCs	Cyclic Redundancy Checks
DAAC	Distributed Active Archive Center
deg	degrees
EASE-Grid	Equal Area Scalable Earth Grid
ECHO	NASA EOS Clearing House
EOS	Earth Observing System
ESA	European Space Agency
FTP	File Transfer Protocol
GMAO	Global Modeling and Assimilation Office
HDF5	Hierarchical Data Format, Version 5
Hz	Hertz
IEEE	Institute of Electrical and Electronics Engineers
JPL	Jet Propulsion Laboratory
km	kilometers
L3	Level-3
LST	Local Solar Time
m	meters
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration
NDVI	Normalized Difference Vegetation Index
NSIDC	National Snow and Ice Data Center
N/A	Not Applicable
QA	Quality Assessment
QC	Quality Control
RFI	Radio Frequency Interference
SAR	Synthetic Aperture Radar
SDS	Science Data System
SCA-H	Single-Channel Algorithm at H polarization
SCA-V	Single-Channel Algorithm at V polarization
SMAP	Soil Moist