SMAP L3 Radar Global Daily 3 km EASE-Grid Soil Moisture, Version 2

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) radar as well as a variety of ancillary data sources. Input backscatter data used to derive soil moisture are resampled to an Earth-fixed, global, cylindrical 3 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
Sensor	SMAP L-Band Radar
Spatial Coverage	Global, between 85.044°N and 85.044°S
Spatial Resolution	3 km
Temporal Coverage	13 April 2015 – 07 July 2015
Temporal Resolution	Daily
Parameters	Soil Moisture Sigma Nought
Data Format	Hierarchical Data Format, Version 5 (HDF5)
Metadata Access	View Metadata Record
Version	V2. Refer to 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)
Get Data	FTP HTTPS Reverb | ECHO Worldview

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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.

Kim, S. B., J. van Zyl, R. S. Dunbar, E. Njoku, J. Johnson, M. Moghaddam, and L. Tsang. 2015. *SMAP L3 Radar Global Daily 3 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:http://dx.doi.org/10.5067/6QFA65R4RPOH. [Date accessed].

1. Detailed Data Description

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 the following main groups, which contain additional groups and/or data sets:

- `Ancillary_Data`
- `Metadata`
- `Radar_Data`
- `Soil_Moisture_Retrieval_Data`

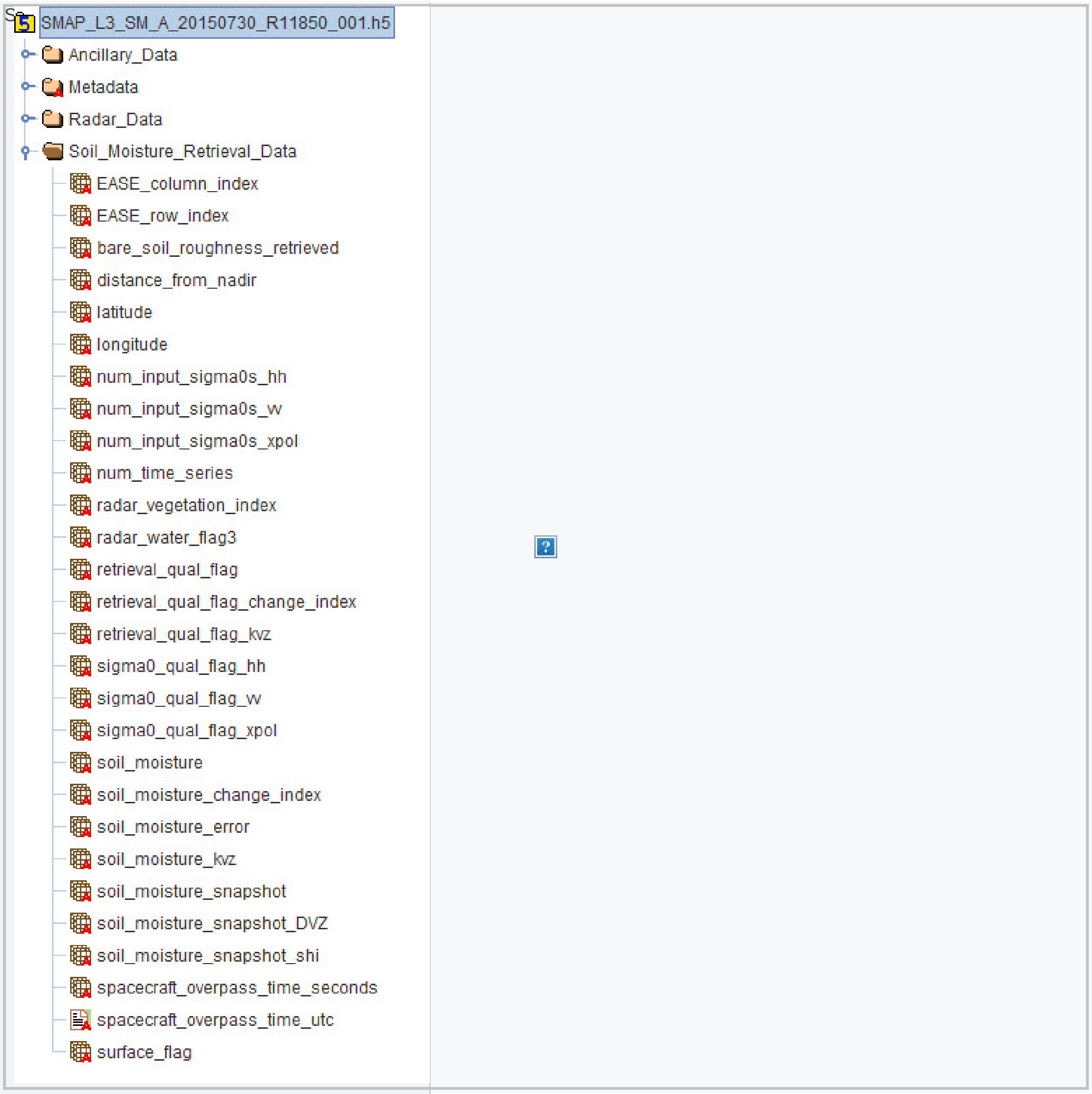

Figure 1. Sample of the HDF5 File Structure

Data Fields Overview

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

Ancillary Data

Includes all ancillary data, such as surface temperature and vegetation water content.

Metadata

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.

Radar Data

Includes all radar data, such as cross-polarized sigma nought (also referred to as sigma0 or σ0) data.

Soil Moisture Retrieval Data

Includes soil moisture 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_A_yyyymmdd_RLVvvv_NNN.[ext]`

For example:

`SMAP_L3_SM_A_20141225_R12130_002.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_A</code></td><td>Indicates specific product (<code>L3</code>: Level-3; <code>SM</code>: Soil Moisture; <code>A</code>: Active)</td></tr>
<tr><td><code>yyyymmdd</code></td><td>4-digit year, 2-digit month, 2-digit day; date in Universal Coordinated Time (UTC) of the first data element that appears in the product.</td></tr>
<tr><td><code>RLVvvv</code></td><td>Composite Release ID, 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 Version Number</td></tr>
<tr><td><code>vvv</code></td><td>3-Digit Minor Version Number</td></tr>
</table>
Example: <code>R12130</code> indicates a standard data product with a version of 2.130.</td></tr>
<tr><td><code>NNN</code></td><td>Number of times the file was generated under the same version for a particular date/time interval (<code>002</code>: 2nd 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/Volume

The daily data volume is approximately 765 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 radar footprint is 1 km. Data are then gridded using the 3 km EASE-Grid 2.0 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 3 x 3 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 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.

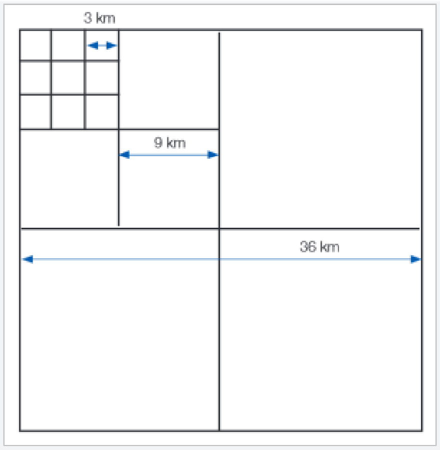

Figure 2. Perfect Nesting in EASE-Grid 2.0

Temporal Coverage

Data were collected from 13 April 2015 to 07 July 2015.

Note: Temporal coverage for this data set is limited due to the premature failure of the SMAP L-Band Radar. On 07 July 2015, the radar stopped transmitting due to an anomaly involving the instrument's high-power amplifier (HPA). For details, refer to the SMAP News Release issued 02 September 2015 by the Jet Propulsion Laboratory (JPL).

Parameter Description

Surface soil moisture (0-5 cm) in cm^3/cm^3 derived from the SMAP radar is output on a fixed 3 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.

Software and Tools

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

3. Data Acquisition and Processing

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 radar soil moisture data (SPL3SMA) are derived from SMAP L2 Radar Half-Orbit 3 km EASE-Grid Soil Moisture, Version 2 (SPL2SMA) data.

Theory of Measurements

Retrieval of soil moisture from measured backscatter data typically implies an inversion of the radar forward scattering process. Bare rough surfaces can be characterized in terms of their root mean square (rms) roughness height, correlation length, and moisture content (a surrogate for dielectric constant). The use of time-series data makes the retrieval a well-constrained estimation problem, under the assumption of a time invariant surface roughness. By taking a co-polarized ratio the soil moisture retrieval becomes insensitive to the correlation length except for very rough surfaces, which enables an accurate retrieval of soil moisture without correlation length information. This approach has been extended to the vegetated surface by introducing a vegetation axis to the lookup table (Kim et al. 2014). A one-axis representation of the vegetation effect is clearly a simplification, considering that different sets of vegetation parameters result in different backscattering coefficients. However, with SMAP's three measurement channels—HH, VV, and HV—at most three independent parameters can be uniquely estimated, and therefore simplified forward models must be represented in terms of at most three dominant parameters. The simplification results in some errors in soil moisture retrieval, especially in heavily vegetated areas such as forests. Allometric relationships reduce the number of unknowns and may improve the retrievals. The three parameters used to simplify the scattering model are then the dielectric constant of soil, ε, soil surface roughness, s and VWC.

The SMAP radar HV-channel measurements are reserved for possible use in correcting vegetation effects. The remaining two co-polarized (co-pol) measurements (HH and VV) are not always sufficient to determine s and ε (Kim et al. 2014). One of the main causes is the ambiguity in bare surface scattering: a wet and smooth surface may have the same backscatter as a dry and moderately rough surface. Very often the timescale of the change in s is longer than that of ε (Jackson et al. 1997). Then s may be constrained to be a constant in time, thus resolving the ambiguity (Kim et al. 2014).

The SMAP baseline approach (Kim et al. 2012; Kim et al. 2014) is a multichannel retrieval algorithm that searches for a soil moisture solution such that the difference between modeled and observed backscatter is minimized in the least squares sense. A look-up table representation, or data cube, of a complicated forward model has been demonstrated to be an accurate and fast tool for retrieval (Kim et al. 2012a; Kim et al. 2014).The algorithm estimates s first and then retrieves ε_r using the estimated s. Vegetation effects are included by selecting the sigma0 of the forward model at the VWC level given by an ancillary source. Note that the VWC provided by ancillary information is allowed to vary throughout the time series.

For in-depth information regarding the physics involved in deriving soil moisture from backscatter, refer to the ATBD for this product, Section 2: Physics of the Scattering Problem.

Derivation Techniques and Algorithms

This SMAP Level-3 radar soil moisture data set is a daily gridded composite of the SMAP L2 Radar Half-Orbit 3 km EASE-Grid Soil Moisture, Version 2 (SPL2SMA) data set. The derivation of soil moisture from SMAP brightness temperatures occurs in the Level-2 processing of the radar data set.

Please refer to the Derivation Techniques section in the SPL2SMA user guide for details on algorithms and ancillary data.

Processing Steps

The SPL3SMA product is a daily global product. This product is generated by the SMAP Science Data Processing System (SDS) at the Jet Propulsion Laboratory (JPL) in Pasadena, California USA. To generate this product, the processing software ingests one day's worth of SPL2SMA granules/files and creates individual global composites as two-dimensional arrays for each output parameter defined in the SPL2SMA product. Wherever data overlap occurs (typically at high latitudes), data whose acquisition times are closest to the 6:00 a.m. local solar times are chosen. Because the input SPL2SMA granules are available only for descending (6:00 a.m.) passes, the resulting SPL3SMA granules are also available only for descending (6:00 a.m.) passes.

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.

More information about error sources is provided in Section 3.5: Error Budget of the ATBD.

Quality Assessment

These Version 2 data are Beta-quality, which means they employ preliminary algorithms that are still being validated and are thus subject to uncertainties.

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 document.

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 HDF5 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 file/granule fails QA, the SDS does not send the granule to NSIDC until it is reprocessed. Level-2 products that fail QA are never delivered to NSIDC. Only a QA file is produced when there are no data that qualify for retrieval.

Quality 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 Quality Flags section in the SPL2SMA user guide.

4. References and Related Publications

Bolten, J., V. Lakshmi, and E. Njoku. 2003. Soil Moisture Retrieval Using the Passive/Active L- and S-band Radar/Radiometer. *IEEE Trans. Geosci. Rem. Sens.*, 41:2792-2801.

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. http://dx.doi.org/10.3390/ijgi1010032.

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. http://dx.doi.org/10.3390/ijgi3031154.

Dunbar, R. S., and S. B. Kim. 2014. SMAP Level 3 Active Soil Moisture (L3_SM_A) Product Specification Document. SMAP Project, JPL D-72550. Jet Propulsion Laboratory, Pasadena, CA. (http://nsidc.org/data/docs/daac/smap/sp_l3_sma/pdfs/D-72550_SMAP L3_SM_A PSD_12082015_wo-sigs.pdf, 476 KB)

Entekhabi, D. et al. 2014. SMAP Handbook–Soil Moisture Active Passive: Mapping Soil Moisture and Freeze/Thaw from Space. Pasadena, CA USA: SMAP Project, JPL CL#14-2285, Jet Propulsion Laboratory.

Jackson, T. J., H. McNairn, M. A. Weltz, B. Brisco, and R. Brown. 1997. First Order Surface Roughness Correction of Active Microwave Observations for Estimating Soil Moisture. *IEEE Trans. Geosci. Remo te Sens.* 35:1065-1069.

Kim, Y., and J. J. van Zyl. 2009. A Time-Series Approach to Estimate Soil Moisture Using Polarimetric Radar Data. *IEEE Trans. Geosci. Remote Sens.* 47:2519-2527.

Kim, Y., and J. J. van Zyl. 2000. On the Relationship Between Polarimetric Parameters. *IEEE Geoscience and Remote Sensing Symposium.* Hawaii, USA.

Kim, S. B., M. Moghaddam, L. Tsang, M. Burgin, X. Xu, and E. G. Njoku, 2014: Models of L-band radar backscattering coefficients over the global terrain for soil moisture retrieval. *IEEE Trans. Geosci. Remote Sens.***,** vol. 52, pp. 1381-1396, 2014.

Kim, S. B., L. Tsang, J. T. Johnson, S. Huang, J. J. van Zyl, and E. G. Njoku, 2012: Soil moisture retrieval using time-series radar observations over bare surfaces. *IEEE Trans. Geosci. Remote Sens.*, 50, 1853-1863.

Kim, S. B., J. van Zyl, S. Dunbar, E. Njoku, J. Johnson, M. Moghaddam, J. Shi, and L. Tsang. 2014. SMAP Algorithm Theoretical Basis Document: L2 & L3 Radar Soil Moisture (Active) Products. SMAP Project, Jet Propulsion Laboratory, Pasadena, CA. (http://nsidc.org/data/docs/daac/smap/sp_l2_sma/pdfs/276_L2_3_SM_A_RevA_web.pdf, 5.4 MB)

Kim, S. B., J. van Zul, T. Jackson, and A. Colliander. 2015. Soil Moisture Active Passive (SMAP) Project Calibration and Validation for the L2/3_SM_A Beta-Release Data Products. SMAP Project, JPL D-XXXX. Jet Propulsion Laboratory, Pasadena, CA. (http://nsidc.org/data/docs/daac/smap/sp_l2_sma/pdfs/L2L3SMA_Assessment_Report151024.pdf, 673 KB)

Kim, S.B., J. Oullette, J. J. van Zyl, and J. T. Johnson, 2015 (In revision). Dual-copolarized approach to detect surface water extent using L-land radar. *IEEE Trans. Geosci. Remote Sens.*

Kim, S.B., J. van Zul, T. Jackson, and A. Colliander. 2015. SMAP Level 2 Active Soil Moisture (L2_SM_A) Beta Release Assessment Report. SMAP Project, JPL D-98985. Jet Propulsion Laboratory, Pasadena, CA.

5. Contacts and Acknowledgments

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