SMAP L1C Radiometer Half-Orbit 36 km EASE-Grid Brightness Temperatures, Version 3

USER GUIDE

How to Cite These Data

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

Chan, S., E. G. Njoku, and A. Colliander. 2016. *SMAP L1C Radiometer Half-Orbit 36 km EASE-Grid Brightness Temperatures, Version 3*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/E51BSP6V3KP7. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/SPL1CTB/versions/3

National Snow and Ice Data Center

TABLE OF CONTENTS

1 DATA DESCRIPTION

1.1 Parameters

Brightness temperature (TB) is a measure of the radiance of the microwave radiation welling upward from the top of the atmosphere to the satellite. The SMAP L-Band Radiometer measures four brightness temperature Stokes parameters: TH, TV, T3, and T4 at 1.41 GHz. TH and TV are the horizontally and vertically polarized brightness temperatures, respectively, and T3 and T4 are the third and fourth Stokes parameters, respectively.

Refer to the Product Specification Document 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 Level-1C brightness temperature product, refer to the Product Specification Document page.

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.

Data fields are stored as one-dimensional arrays of size *N*, where *N* is the number of valid cells covered by the radiometer swath on the grid. Note that *N* varies with projections, but remains the same for both fore-looking and aft-looking views within a given projection.

1.2.3.1 Global Projection

In the global EASE-Grid 2.0 projection, includes data that represent fore- and aft-looking views of the 360° antenna scan. Contains brightness temperature observations, instrument viewing geometry information, and quality bit flags.

1.2.3.2 North Polar Projection

In the north polar EASE-Grid 2.0 projection, includes data that represent fore- and aft-looking views of the 360° antenna scan. Contains brightness temperature observations, instrument viewing geometry information, and quality bit flags.

1.2.3.3 South Polar Projection

In the south polar EASE-Grid 2.0 projection, includes data that represent fore- and aft-looking views of the 360° antenna scan. Contains brightness temperature observations, instrument viewing geometry information, and quality bit 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 Naming Convention

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

```
SMAP_L1C_TB_[Orbit#]_[A/D]_yyyymmddThhmmss_RLVvvv_NNN.[ext]
```

For example:

```
SMAP_L1C_TB_03895_D_20160113T000349_R13080_001.h5
```

Table 1. File Naming Convention

<table>
<tr><th>Variable</th><th>Description</th></tr>
<tr><td>SMAP</td><td>Indicates SMAP mission data</td></tr>
<tr><td>L1C_TB</td><td>Indicates specific product (L1C: Level-1C; TB: Brightness Temperature)</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.</td></tr>
<tr><td>[A/D]</td><td>Half-orbit pass of the satellite, such as:
A: Ascending (where satellite moves from South to North, and 6:00 p.m. is the local solar equator crossing time)
D: Descending (where satellite moves from North to South, and 6:00 a.m. is the local solar equator crossing time)</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>
</table>

<table>
<tr><th>Variable</th><th>Description</th></tr>
<tr><td>RLVvvv</td><td>Composite Release ID, 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 Version Number</td></tr><tr><td>vvv</td><td>3-Digit Minor Version Number</td></tr></table>Example: R13242 indicates a a standard data product with a version of 3.242. 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>
<tr><td>.[ext]</td><td>File extensions include:<table><tr><td>.h5</td><td>HDF5 data file</td></tr><tr><td>.qa</td><td>Quality Assurance file</td></tr><tr><td>.xml</td><td>XML Metadata file</td></tr></table></td></tr>
</table>

1.2.6 File Size

Each half-orbit file is approximately 4.6 MB.

1.2.7 File Size

The daily data volume is approximately 174 MB.

1.3 Spatial Information

1.3.1 Coverage

Coverage spans from 180°W to 180°E, and from approximately 85.044°N and 85.044°S for the EASE-Grid, Version 2.0. 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.

1.3.2 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.

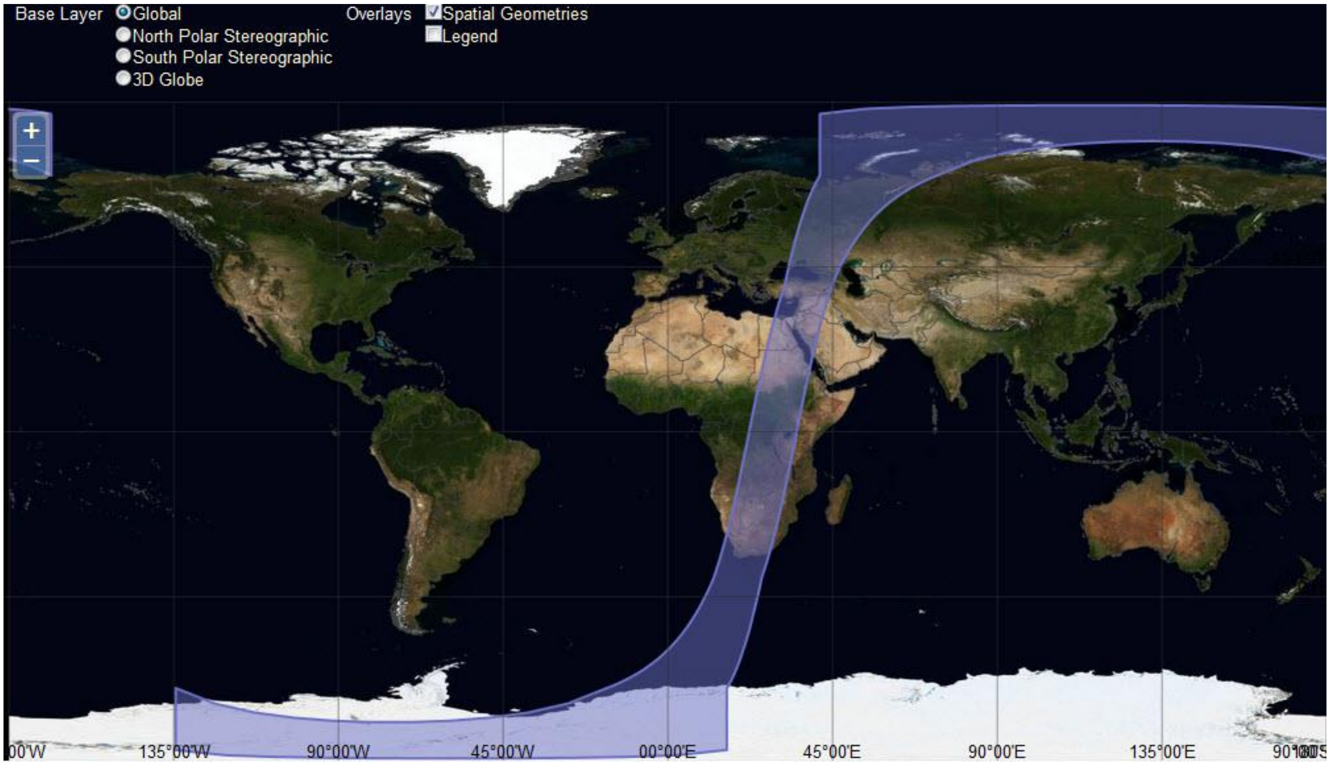

Figure 2. Spatial Coverage Map displaying one descending half orbit of the SMAP L-Band Radiometer. The map was created using the Reverb | ECHO tool.

1.3.3 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 projection.

1.3.4 Projection and Grid Description

These data are provided on the EASE-Grid 2.0 (Brodzik et al. 2012) in three different equal-area projections: a global cylindrical, and both a Northern and Southern Hemisphere azimuthal. Each grid cell has a nominal area of approximately 36 x 36 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 to a resolution of 3 km (4872 rows x 11568 columns on global coverage), 9 km (1624 rows x 3856 columns on global coverage), and 36 km (406 rows x 964 columns on global coverage).

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.

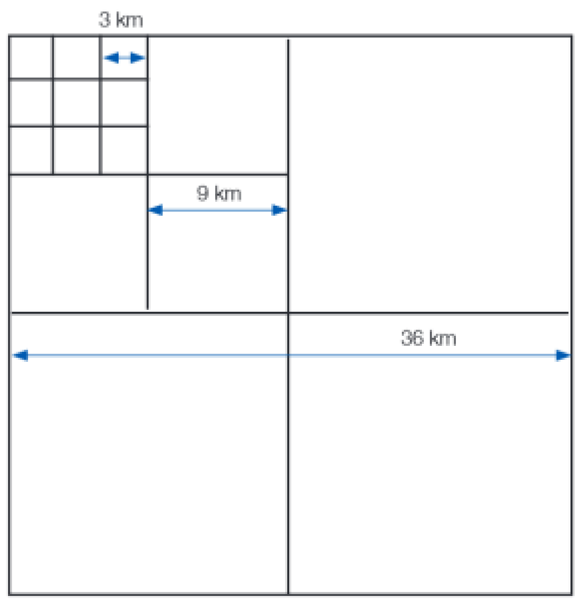

Figure 3. Perfect Nesting in EASE-Grid 2.0

1.4 Temporal Information

1.4.1 Coverage

Coverage spans from 31 March 2015 to present.

1.4.2 Temporal Coverage Gaps

1.4.2.1 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

1.4.2.2 Latencies

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

1.4.3 Temporal Resolution

Each Level-1C half-orbit file spans approximately 49 minutes.

2 DATA ACQUISITION AND PROCESSING

2.1 Background

This section has been adapted from Chan et al. (2014).

2.2 Sensor or Instrument Description

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

2.3 Data Source

SMAP L1B Radiometer Half-Orbit Time-Ordered Brightness Temperatures, Version 3 (SPL1BTB) are used as input to calculating this Level-1C brightness temperature product.

2.4 Theory of Measurements

The Level-1C brightness temperature product is a gridded version of SMAP L1B Radiometer Half-Orbit Time-Ordered Brightness Temperatures, Version 3 and thus shares most of the same major output data fields, data granularity (one half-orbit per file), and theory of measurements. Refer to Level-1B Theory of Measurements for more details.

2.5 Derivation Techniques and Algorithms

2.5.1 Gridding Algorithm

The gridding algorithm for this product uses the Inverse-Distance-Squared (IDS) method often used in microwave radiometry applications. All brightness temperature data samples that fall within a grid cell are averaged with weights varying inversely with the square of the radial distance between the data samples and the grid cell center:

$$T_{Bg} = \frac{1}{A}\sum_{i=1}^{N} \alpha_i T_{Bi}$$ **(Equation 1)**

$$A = \sum_{i=1}^{N} \alpha_i$$ **(Equation 2)**

$$\alpha_i = \frac{1}{d_i^2}$$ **(Equation 3)**

and *di* is the great-circle distance between the data sample TB*i* and the grid cell center, given by:

$$d_i = R_E \arccos[\sin\emptyset_i \sin\emptyset_o + \cos\emptyset_i \cos\emptyset_o \cos(\lambda_i - \lambda_o)]$$ (**Equation 4)**

Here, (Φi, λi) and (Φo, λo) are the latitudes and longitudes of the data sample *i* and grid cell center *o*, respectively. *RE* (6378 km) is the radius of the Earth.

For more information, refer to the ATBD for this product.

2.6 Processing Steps

This product is generated by the SMAP Science Data Processing System (SDS) at JPL in Pasadena, California USA. To generate the product, the processing software ingests a half-orbit file of the SMAP L1B Radiometer Half-Orbit Time-Ordered Brightness Temperatures, Version 3 product. Based on the geometry and geolocation information, the data are then remapped onto an Earth-fixed grid using the IDS gridding algorithm, which includes the following steps:

1. Determine the 36 km EASE-Grid 2.0 row and column indices corresponding to the latitude and longitude of each observation
2. Identify all brightness temperature data samples that are within *X* km of each EASE-Grid 2.0 cell center
3. Apply averaging to these data samples
4. Assign the computed result to the grid cell
5. Repeat Steps 2–4 above for all other grid cells

The Level-1C processor applies the gridding algorithm to a half-orbit Level-1B brightness temperature file and converts it into a corresponding half-orbit Level-1C brightness temperature file. The Level-1C processing is essentially a remapping of time-ordered swath data onto a grid. The input Level-1B and output Level-1C data share the same granularity (one half orbit per file). There is no geophysical processing performed; for example, no brightness temperature correction is performed for fractional water within the antenna Field of View (FOV). The gridding algorithm is applied to the brightness temperatures and other applicable parameters in the Level-1B product file (latitude, longitude, azimuth angle, incidence angle, reflected sun angles, etc.). Quality flags are logically OR-ed together; if an individual quality flag for Level-1B brightness temperature contributing to the average is set, that flag is set for the grid cell average.

2.7 Quality, Error Sources, Limitations

2.7.1 Errors

This Level-1C brightness temperature product is a gridded version of the SMAP L1B Radiometer Half-Orbit Time-Ordered Brightness Temperatures, Version 3 product. Thus, the output Level-1C brightness temperature data inherit the input Level-1B Error Sources, primarily RFI and radiometric noise and calibration error, modified by the process of gridding the input brightness temperature data samples onto an Earth-fixed grid. The gridding process does not affect the calibration errors, such as biases and drifts, but will reduce the radiometric noise, such as the random component of the brightness temperature error. Conversely, the gridding process will enlarge the effective antenna pattern footprint of the brightness temperature measurement, thereby coarsening the spatial resolution. Depending on the brightness temperature heterogeneity of the observed scene, the decrease in spatial resolution may increase the error in representing the brightness temperature of a given point on the surface.

For more information on the noise versus resolution trade-off, please refer to the ATBD for this product.

2.7.2 Quality Assessment

For in-depth details regarding the quality of these Version 3 Validated data, refer to the following reports:
Validated Assessment Report
Beta Assessment Report

Each HDF5 file contains metadata with Quality Assessment (QA) metadata flags that are set by the 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 DAAC 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.

Various levels of QA are conducted with Level-1C data. 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.

In addition, during the post-launch Calibration/Validation period, the performance of the Level-1C brightness temperature product relative to the Level-1B brightness temperature product are evaluated in a number of ways. These include:

- Comparing images and examining differences between the two products over coastlines and other discrete boundaries, and heterogeneous terrain (lakes, mountains, rivers).
- Comparing TB and TB-gradient histograms of the two products over regions of varying heterogeneity.

Refer to the Product Specification Document for details on all data flags.

3 SOFTWARE AND TOOLS

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

4 CONTACTS AND ACKNOWLEDGMENTS

Steven Chan, Eni Njoku, Andreas Colliander
Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Dr.
Pasadena, CA 91109 USA

5 REFERENCES

Brodzik, M. J., B. Billingsley, T. Haran, B. Raup, and M. H. Savoie. 2014. Correction: Brodzik, M. J. et al. 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.

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.

Chan, S., Njoku, E., Colliander, A. 2014. SMAP Algorithm Theoretical Basis Document (ATBD) Level-1C Radiometer Data Product (L1C_TB). SMAP Project, Jet Propulsion Laboratory, Pasadena, CA. (PDF, 3 MB)

Chan, Steven, and R. Scott Dunbar. 2015. SMAP Level 1C Radiometer (L1C_TB) Product Specification Document. Pasadena, CA: SMAP Project, JPL D-72545, Jet Propulsion Laboratory. (PDF, 1 MB)

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.

Piepmeier, Jeffrey, Steven Chan, Julian Chaubell, Jinzheng Peng, Rajat Bindlish, Alexandra Bringer, Andreas Colliander, Giovanni De Amici, E. P. Dinnat, Derek Hudson, Tom Jackson, Joel Johnson, David Le Vine, Thomas Meissner, Sidharth Misra, Priscilla Mohammed, Dara Entekhabi, and Simon Yueh. 2016. SMAP Radiometer Brightness Temperature Calibration for the L1B_TB, L1C_TB (Version 3), and L1C_TB_E (Version 1) Data Products, SMAP Project, JPL D-56295, Jet Propulsion Laboratory, Pasadena, CA. (PDF, 1.4 MB)

Piepmeier, J. R. et al. 2015. SMAP Algorithm Theoretical Basis Document: L1B Radiometer Product. SMAP Project, NASA GSFC SMAP-006, NASA Goddard Space Flight Center, Greenbelt, MD. (PDF, 6 MB)

Piepmeier, J. and S. Chan. 2015a. Soil Moisture Active Passive (SMAP) Project Radiometer Brightness Temperature Calibration for the L1B_TB and L1C_TB Validated Version 2 Data Products. SMAP Project, JPL D-93718. Jet Propulsion Laboratory, Pasadena, CA. (PDF, 1 MB)

Piepmeier, J. and S. Chan. 2015b. Soil Moisture Active Passive (SMAP) Project Radiometer Brightness Temperature Calibration for the L1B_TB and L1C_TB Beta-Level Data Products. SMAP Project, JPL D-93978. Jet Propulsion Laboratory, Pasadena, CA. (PDF, 3.15 MB)

6 DOCUMENT INFORMATION

6.1 Publication Date

October 2015

6.2 Date Last Updated

October 2015