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

This Level-1C (L1C) product contains calibrated, geolocated, time-ordered brightness temperatures acquired by the Soil Moisture Active Passive (SMAP) radiometer during 6:00 a.m. descending and 6:00 p.m. ascending half-orbit passes. Input SMAP L-band Level-1B brightness temperature data were resampled to an Earth-fixed, 36 km Equal-Area Scalable Earth Grid, Version 2.0 (EASE-Grid 2.0) in three projections: global cylindrical, north polar, and south polar. This L1C product is a gridded version of the SMAP Level-1B radiometer brightness temperature product.

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

Overview

Platform	Soil Moisture Active Passive Observatory
Sensors	SMAP L-Band Radiometer
Spatial Coverage	Global, between 85.044°N and 85.044°S
Spatial Resolution	36 km
Temporal Coverage	31 March 2015 – present **Note:** Data will be made available as they are processed; see the Notice Regarding Data Availability.
Temporal Resolution	49 minutes
Parameters	Brightness Temperatures
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.

Chan, S., Njoku, E., Colliander, A. 2015. *SMAP L1C Radiometer Half-Orbit 36 km EASE-Grid Brightness Temperatures*. 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/RP9DZ1CC6XNP.

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:

- `Global_Projection`

- Metadata
- North_Polar_Projection
- South_Polar_Projection

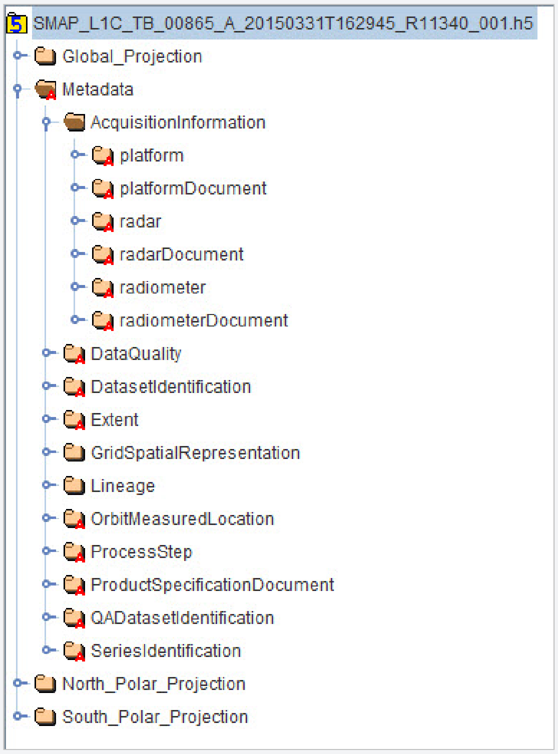

Figure 1. Sample of the HDF5 File Structure

Data Fields Overview

Each Level-1C radiometer brightness temperature file contains the following:

Global 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.

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.

North Polar 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.

South Polar 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.

Note: Data from the fore- and aft-look portions of the 360° antenna scan are provided separately in order to benefit radiometric analyses over regions where there is strong brightness temperature (TB) azimuthal dependence.

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_L1C_TB_[Orbit#]_[A/D]_yyyymmddThhmmss_RLVvvv_NNN.[ext]

For example:

SMAP_L1C_TB_00934_D_20141225T074951_R14001_002.h5

Where:

Table 1. File Naming Conventions

Variable	Description
SMAP	Indicates SMAP mission data
L1C_TB	Indicates specific product (L1C: Level-1C; TB: Brightness Temperature)
[Orbit#]	5-digit sequential number of the orbit flown by the SMAP spacecraft when data were acquired. Orbit 00000 began at launch.
[A/D]	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)
yyyymmddThhmmss	Date/time in Universal Coordinated Time (UTC) of the first data element that appears in the product, where: yyyymmdd: 4-digit year, 2-digit month, 2-digit day T: Time (delineates the date from the time, i.e. yyyymmdd***T***hhmmss) hhmmss: 2-digit hour, 2-digit month, 2-digit second
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 a standard data product with a version of 4.001.
NNN	Number of times the file was generated under the same version for a particular date/time interval (002: 2nd time)
.[ext]	File extensions include: .h5: HDF5 data file .qa: Quality Assurance file .xml: XML Metadata file

File Size

Each half-orbit file is approximately 5 MB using HDF compression.

Volume

The daily data volume is approximately 20 MB.

Spatial 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.

Spatial Coverage Map

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

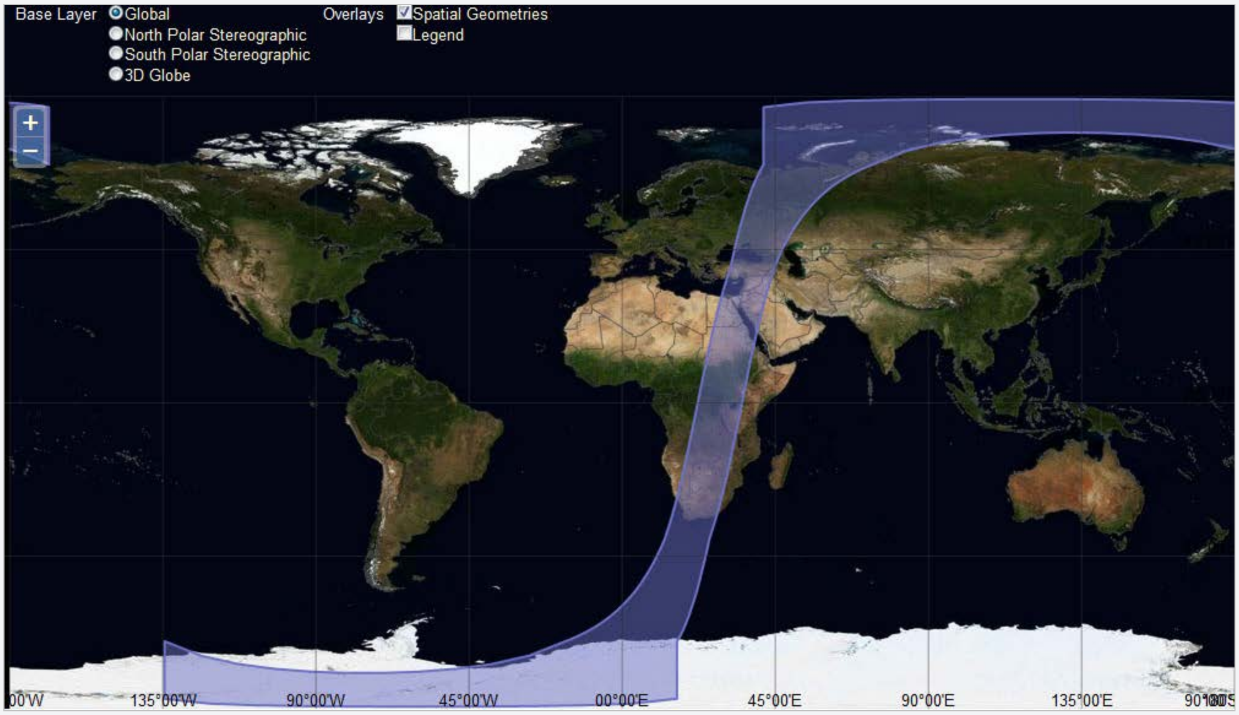

Figure 2. Spatial Coverage Map displaying one descending half orbit of the SMAP L-Band Radiometer. The map was created using the Reverb | ECHO tool.

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 projection.

Projection and Grid Description

EASE-Grid 2.0

These data are provided on the EASE-Grid 2.0 (Brodzik et al. 2012) in three different equal-area projections: a global cylindrical, and a Northern and Southern hemisphere azimuthal.

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 2.0 Format Description.

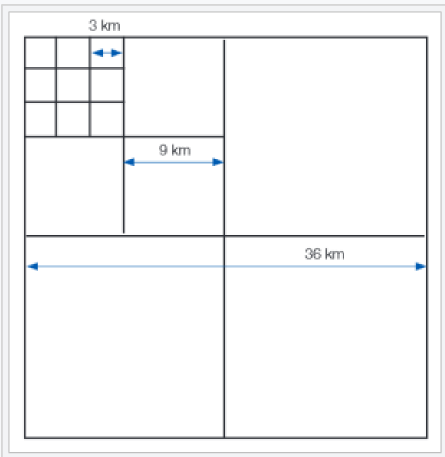

Figure 3. Perfect Nesting in EASE-Grid 2.0

Temporal Coverage

Data were collected from 31 March 2015 to present.

31 July 2015 — Notice Regarding Data Availability
As of 30 July 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 twelve hours of satellite observation. In addition, reprocessing of data from 31 March 2015 to 29 July 2015 to Version 1 has also begun and data will be made available as they are processed. This reprocessing is expected to be completed in the coming weeks.

Temporal Resolution

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

Parameter Description

The SMAP 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 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, refer to the Tools Web page.

3. Data Acquisition and Processing

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

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.

Data Source

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

Theory of Measurements

The Level-1C brightness temperature product is a gridded version of SMAP L1B Radiometer Half-Orbit Time-Ordered Brightness Temperatures 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.

Derivation Techniques and Algorithms

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)**

Where:

$$A = \sum_{i=1}^{N} \alpha_i$$ **(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.

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 granule of the SMAP L1B Radiometer Half-Orbit Time-Ordered Brightness Temperatures, Version 1 product. Based on the geometry and geolocation information, the data are then remapped onto an Earth-fixed grid using the IDS gridding algorithm.

The processing computations involve the following steps:

1. Transform (lat, lon) of input data to decimal values of 36 km EASE-Grid 2.0 row and column indices
2. Identify brightness temperature data samples within a given grid cell
3. Apply the gridding algorithm 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 granule and converts it into a corresponding half-orbit Level-1C brightness temperature granule. 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 treated differently; if the individual quality flag for Level-1B brightness temperature contributing to the average is set, that flag is set for the grid cell average.

Error Sources

This Level-1C brightness temperature product is a gridded version of the SMAP L1B Radiometer Half-Orbit Time-Ordered Brightness Temperatures 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.

Quality Assessment

Though SMAP Level-1 radiometer data are available from 31 March 2015, these Beta-level 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 Beta-level data, refer to the following report:
Soil Moisture Active Passive (SMAP) Project Radiometer Brightness Temperature Calibration for the L1B_TB and L1C_TB Beta-Level Data Products

Quality Overview

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. Various levels of QA are conducted with Level-1A 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 file/granule fails QA, the SDS does not send the granule to NSIDC DAAC until it is reprocessed. Level-1C products that fail QA are never delivered to NSIDC DAAC. Only a QA file is produced when there are no Level-1C brightness temperature data that qualify for retrieval.

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 will be 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 Data Fields document for details on all data flags.

4. References and Related Publications

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. (https://nsidc.org/sites/nsidc.org/files/files/279_L1C_TB_ATBD_RevA_web.pdf, 3 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, J.R., D.G. Long, and E.G. Njoku. 2008. Stokes Antenna Temperatures. *IEEE Trans. Geosci. Remote Sens.* 46(2):516-527.

5. Contacts and Acknowledgments

Investigators

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

Technical Contact

NSIDC User Services
National Snow and Ice Data Center
CIRES, 449 UCB
University of Colorado
Boulder, CO 80309-0449 USA
phone: +1 303.492.6199
fax: +1 303.492.2468
form: Contact NSIDC User Services
e-mail: nsidc@nsidc.org

6. Document Information

Acronyms and Abbreviations

Table 3 defines the acronyms and abbreviations used in this document.

Table 3. Acronyms and Abbreviations

Acronym	Description
ATBD	Algorithm Theoretical Basis Document
DAAC	Distributed Active Archive Center

deg	degrees
deg/sec	degrees per second
deg C	degrees Celsius
EASE-Grid	Equal Area Scalable Earth Grid
FOV	Field of View
FTP	File Transfer Protocol
GByte	gigabyte
GHz	gigahertz
HDF5	Hierarchical Data Format, Version 5
IDS	Inverse Distance Squared
JPL	Jet Propulsion Laboratory
km	kilometers
L1C	Level-1C
LST	Local Solar Time
m	meters
NASA	National Aeronautics and Space Administration
NSIDC	National Snow and Ice Data Center
N/A	Not Applicable
PSD	Product Specification Document
QA	Quality Assurance
RFI	Radio Frequency Interference
SDS	Science Data Processing System
SMAP	Soil Moisture Active Passive