

SMAP L1B Radiometer Half-Orbit Time-Ordered Brightness Temperatures

This Level-1B (L1B) product provides calibrated estimates of time-ordered geolocated brightness temperatures measured by the Soil Moisture Active Passive (SMAP) passive microwave radiometer. Brightness temperatures are referenced to the Earth's surface with undesired and erroneous radiometric sources removed. Sources of contamination include Faraday rotation, energy detected from antenna sidelobes and spillover, atmospheric effects, solar radiation, lunar radiation, cosmic microwave background, and galactic emission.

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 86.4°N and 86.4°S
Spatial Resolution	36 x 47 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) Bit Errors (Due to noise in communication links and memory storage devices)
Get Data	FTP HTTPS Reverb ECHO Worldview Subscription

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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.

Piepmeyer, J. R., P. N. Mohammed, J. Peng, E. Kim, G. De Amici, and C. Ruf. 2015. *SMAP L1B Radiometer Half-Orbit Time-Ordered 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/10.5067/1V33MVRRLCCT>.

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:

- Brightness_Temperature
- Calibration_Data

- High_Resolution_Calibration_Data
- Metadata
- Spacecraft_Data

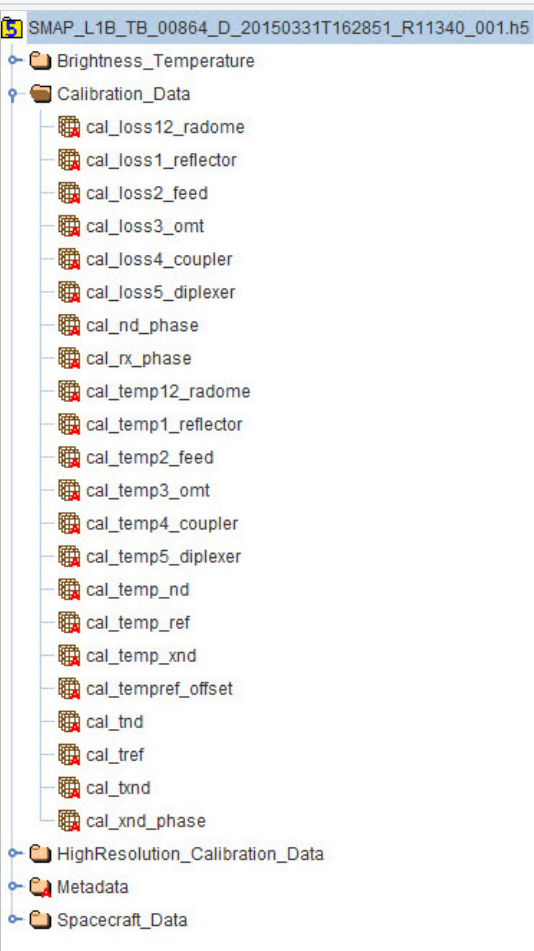


Figure 1. Sample of the HDF5 File Structure

Data Fields Overview

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

Brightness Temperature

Includes brightness temperatures (TBs) at each footprint referenced to the surface of the Earth with error sources removed. Undesirable radiometric sources (such as atmospheric effects and solar, lunar, and galactic emissions) are also removed. Also includes error source values, brightness temperature error, and Noise Equivalent Delta Temperature (NEDT). Many parameters are specifically designated for horizontal and vertical polarizations as well as the 3rd and 4th Stokes parameters.

Calibration Data

Includes fullband and subband calibration coefficients. Among these coefficients are instrument component losses, noise temperatures, physical temperatures, calibration gain and offset factors and phase values. The contents were corrected for detected RFI.

High Resolution Calibration Data

Includes subband calibration coefficients. Among these coefficients are instrument component losses, noise temperatures, physical temperatures, calibration gain and offset factors and phase values. The contents were corrected for detected RFI.

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.

Spacecraft Data

Includes elements that specify either geometric or geographic information that are representative of each entire antenna scan of the instrument swath. Major elements include the spacecraft time, position, velocity, and attitude. Values in the spacecraft data group are representative of all brightness temperatures acquired during the corresponding antenna scan.

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_L1B_TB_[Orbit#]_[A/D]_yyyymmddThhmss_RLVvvv_NNN.[ext]

For example:

SMAP_L1B_TB_00934_D_20141225T074951_R14001_002.h5

Where:

Table 1. File Naming Conventions

Variable	Description								
SMAP	Indicates SMAP mission data								
L1B_TB	Indicates specific product (L1B: Level-1B; 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. Orbit numbers increment each time the spacecraft flies over the southernmost point in the orbit path.								
[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 time) D: Descending (where satellite moves from North to South, and 6:00 a.m. is the local solar time)								
yyyymmddThhmss	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. yyyymmddThhmss)</td></tr><tr><td>hhmmss</td><td>2-digit hour, 2-digit month, 2-digit second</td></tr></table>	yyyymmdd	4-digit year, 2-digit month, 2-digit day	T	Time (delineates the date from the time, i.e. yyyymmddThhmss)	hhmmss	2-digit hour, 2-digit month, 2-digit second		
yyyymmdd	4-digit year, 2-digit month, 2-digit day								
T	Time (delineates the date from the time, i.e. yyyymmddThhmss)								
hhmmss	2-digit hour, 2-digit month, 2-digit second								
RLVvvv	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: R14001 indicates a post-launch data product with a version of 4.001.	R	Release	L	Launch Indicator (1: post-launch standard data)	V	1-Digit Major Version Number	vvv	3-Digit Minor Version Number
R	Release								
L	Launch Indicator (1: post-launch standard data)								
V	1-Digit Major Version Number								
vvv	3-Digit Minor Version Number								
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: <table><tr><td>.h5</td><td>HDF5 data file</td></tr><tr><td>.qa</td><td>Quality Assurance file</td></tr><tr><td>.h5.iso.xml</td><td>XML Metadata file</td></tr></table>	.h5	HDF5 data file	.qa	Quality Assurance file	.h5.iso.xml	XML Metadata file		
.h5	HDF5 data file								
.qa	Quality Assurance file								
.h5.iso.xml	XML Metadata file								

File Size

Each half-orbit file is approximately 46 MB using HDF compression.

Volume

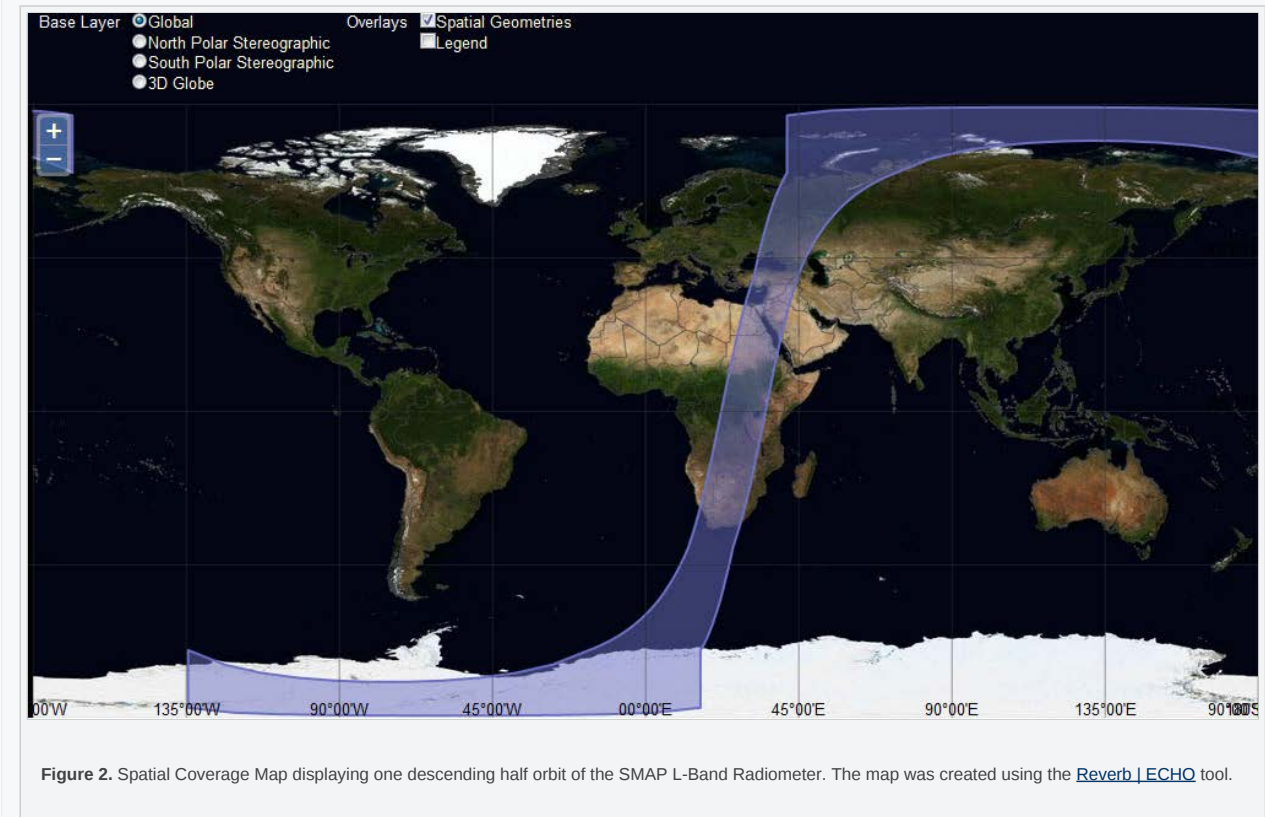
The daily data volume is approximately 185 MB.

Spatial Coverage

Coverage spans from 180°W to 180°E, and from approximately 86.4°N to 86.4°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 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.



Spatial Resolution

The instantaneous field of view of the radiometer footprint is approximately 36 x 47 km; the effective field of view of brightness temperatures in the Level-1B brightness temperature product is 39 x 47 km.

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-1B half-orbit file spans approximately 49 minutes.

Parameter Description

The SMAP radiometer measures the four Stokes parameters: TV, TH, T3, and T4 at 1.41 GHz. These parameters represent the vertically and horizontally polarized brightness

temperatures, and the third and fourth cross-polarized brightness temperatures, respectively. The cross-polarized T3-channel measurement can be used to correct for possible Faraday rotation caused by charged particles in the upper atmosphere.

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.

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 [Piepmeier et al. \(2015\)](#).

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 Level-1B radiometer brightness temperatures are processed from [SMAP L1A Radiometer Time-Ordered Parsed Telemetry, Version 1](#) that are generated by the Jet Propulsion Laboratory (JPL). The Level-1A radiometer product contains parsed radiometer instrument telemetry.

Theory of Measurements

The objective of the Level-1B brightness temperature algorithm is to convert digital counts in the instrument telemetry into into time-ordered, geolocated brightness temperatures within the main beam referenced to the Earth's surface. The algorithm theory is similar to what has been developed and implemented for decades for other satellite radiometers. SMAP includes two key features heretofore absent from satellite-borne radiometers: RFI detection and mitigation, and measurement of the third and fourth Stokes parameters using digital correlation.

This section contains a description of the sources contributing to the total apparent temperature seen at the input to the SMAP main reflector. The brightness temperature of a source (measured in kelvins) can be described in terms of the product of the physical temperature and the emissivity of the source. Emissivity is, in general, polarization-dependent, thus differentiating brightness temperature into and for the vertical and horizontal polarizations, respectively. These are the first two modified Stokes parameters. The real part of the complex correlation between these two components is measured by the third modified Stokes parameter, represented in brightness temperatures as T3. The fourth Stokes parameter, T4 measures the imaginary part of the correlation. For this document, a vector of modified Stokes parameters is shown by:

$$\overline{T}_B(\theta, \phi) = \begin{bmatrix} T_v \\ T_h \\ T_3 \\ T_4 \end{bmatrix}$$

(Equation 1)

where θ and Φ are the elevation and azimuth of a spherical coordinate system centered on the radiometer antenna boresight vector. Important sources of radiation at L-band are the Earth's land and sea, the cosmic background radiation, the sun, radiation sources outside our solar system, and the moon.

For an in-depth description of the theory of these measurements, refer to Section 4: Forward Model (TA to TB) of the [ATBD](#) for this product.

Derivation Techniques and Algorithms

The raw radiometer instrument counts are converted to brightness temperatures to produce SMAP Level-1A and Level-1B products. The input data to the Level-1B brightness temperature algorithm are the [SMAP L1A Radiometer Time-Ordered Parsed Telemetry, Version 1](#) data. The Level-1A Science Processing Software produces the Level-1A product in accordance with the Earth Observing System (EOS) Data Product Levels definition, which states that Level-1A data products are reconstructed, unprocessed instrument data at full resolution, are time-referenced and annotated with ancillary information.

The Level-1B radiometer brightness temperature Science Processing Software geolocates and radiometrically calibrates the Level-1A data to obtain antenna temperatures (TA). Subsequent processing performs algorithms that detect and flag pixels for RFI. The data are then time and frequency averaged near the antenna's angular Nyquist rate. Finally, the Level-1B algorithm removes sources of error or sources of radiometric energy not associated with emissivity of the Earth's surface. Those sources include Faraday rotation, energy detected by antenna sidelobes and spillover, atmospheric effects, solar radiation, lunar radiation, cosmic microwave background, and galactic emission.

For more details regarding the algorithm used to generate this product, refer to Section 5: Calibration Algorithm of the [ATBD](#) for this product.

Processing Steps

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 both descending and ascending half-orbit granules of the Level-1A brightness temperature data. The descending half orbits contain data acquired at very nearly 6:00 a.m. local solar time. The ascending half orbits contain data acquired at very nearly 6:00 p.m. local solar time.

The total number of radiometer science packets per antenna scan varies depending on the antenna rotation rate and integration time of the instrument. The resulting number of antenna footprints per scan is therefore variable. To preserve the shape of stored data elements, the size of certain dimensions is assigned a maximum value. Thus, fill values appear in the SMAP Level-1B brightness temperature product when a particular scan does not contain the maximum possible number of footprints.

Antenna Temperatures (TAs) are processed by RFI detection and mitigation algorithms where the pixels for a footprint that are flagged for RFI are removed and the remaining clean pixels are averaged to form an RFI-free antenna footprint. If all pixels for a particular footprint are flagged for RFI then the footprint antenna temperature is assigned the null value. The corresponding footprint brightness temperature (TB) value will also be assigned the null value since the RFI-free antenna footprint antenna temperatures are used to produce the time-ordered brightness temperature product. Subsequently, after pixels with RFI are flagged and dropped, the remaining clean pixels are used to compute the NEDT for that footprint. If all pixels are removed, the null value is assigned to the NEDT for that footprint.

Error Sources

L-Band anthropogenic Radio Frequency Interference (RFI), principally from ground-based surveillance radars, can contaminate radiometer measurements. Early measurements and results from the European Space Agency Soil Moisture and Ocean Salinity (SMOS) mission indicate that, in some regions, RFI is present and detectable. The SMAP radiometer electronics and algorithms have been designed to include features to mitigate the effects of RFI. To combat this, the SMAP radiometer implements a combination of time and frequency diversity, kurtosis detection, and the use of 3rd and 4th Stokes parameter thresholds to detect and where possible mitigate RFI. Data elements associated with subbands are included in the Level-1B radiometer product to track and enable RFI detection and mitigation.

The input Level-1A radiometer data can also contain bit errors caused by noise in communication links and memory storage devices. The packets produced by the Consultative Committee on Space Data Systems (CCSDS) include error-detecting Cyclic Redundancy Checks (CRCs), which the Level-1A processor uses to flag errors.

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

SMAP products provide multiple means to assess quality. Each product contains bit flags, uncertainty measures, and file-level metadata that provide quality information. The [Data Fields](#) document describes the specific bit flags, uncertainty measures, and file-level metadata contained in this product.

A Quality Assessment (QA) file is also associated with each SMAP data product. Each HDF5 file contains metadata with QA metadata flags that are set by the Science Data Processing System (SDS) at JPL prior to delivery to 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 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.

Refer to the [Data Fields](#) document for details on all data flags.

4. References and Related Publications

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. et al. 2015. SMAP Algorithm Theoretical Basis Document: L1B Radiometer Product. SMAP Project, NASA GSFC SMAP-006, NASA Goddard Space Flight Center, Greenbelt, MD. (https://nsidc.org/sites/nsidc.org/files/files/278_L1B_TB_RevA_web.pdf, 6 MB)

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

**Jeffrey R. Piepmeier, Priscilla N. Mohammed,
Jinzheng Peng, Edward Kim, and Giovanni De Amici**
NASA Goddard Space Flight Center
8800 Greenbelt Rd.
Greenbelt, MD 20771 USA

Chris Ruf
Space Physics Research Laboratory
College of Engineering
University of Michigan
Ann Arbor, MI 48109-2143 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
CCSDS	Consultative Committee on Space Data Systems
CRC	Cyclic Redundancy Check
DAAC	Distributed Active Archive Center
EASE-Grid	Equal Area Scalable Earth Grid
ESA	European Space Agency
ESDT	Earth Science Data Type
FTP	File Transfer Protocol
GB	Gigabyte
H	Horizontal Polarization, or H-pol
HDF5	Hierarchical Data Format, Version 5
Hz	Hertz
ISO	International Organization for Standardization
JPL	Jet Propulsion Laboratory
km	kilometers
L1B	Level-1B
MHz	Megahertz

NASA	National Aeronautics and Space Administration
NEDT	Noise Equivalent Delta Temperature
NSIDC	National Snow and Ice Data Center
N/A	Not Applicable
PRI	Pulse Repetition Interval
PSD	Product Specification Document
QA	Quality Assessment
RFI	Radio Frequency Interference
SDS	Science Data System
SIPS	Science Investigator-led Processing System
SMAP	Soil Moisture Active Passive
SMOS	Soil Moisture Ocean Salinity
sec	seconds
USDA/ARS	United States Department of Agriculture/Agricultural Research Service
UTC	Coordinated Univers

