SMAP L1A Radiometer Time-Ordered Parsed Telemetry, Version 2

Each Level-1A (L1A) file incorporates all radiometer data downlinked from the Soil Moisture Active Passive (SMAP) spacecraft for one specific half orbit. The data are scaled instrument counts of the following:

- The first four raw moments of the fullband channel for both vertical and horizontal polarizations
- The complex cross-correlations of the fullband channel
- The 16 subband channels for both vertical and horizontal polarizations

Overview

Platform	SMAP Observatory
Sensor	SMAP L-Band Radiometer
Spatial Coverage	Global, between 86.4°N and 86.4°S
Spatial Resolution	40 km
Temporal Coverage	31 March 2015 – present
Temporal Resolution	49 minutes
Parameter	Instrument Counts
Data Format	Hierarchical Data Format, Version 5 (HDF5)
Metadata Access	View Metadata Record
Version	V2. See the SMAP Data Versions page for version information. **Maturity State:** Validated
Error Sources	Radio Frequency Interference (RFI) Bit Errors (Due to noise in communication links and memory storage devices)
Get Data	FTP HTTPS Reverb | ECHO 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.

Piepmeier, J. R., E. J. Kim, P. N. Mohammed, J. Peng, and C. Ruf. 2015. *SMAP L1A Radiometer Time-Ordered Parsed Telemetry*. 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/JGV8EY3FGAH1. [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/granule is organized into the following main groups, which contain additional groups and/or data sets:

- `HighResolution_Moments_Data`
- `House_Keeping_Data`
- `Metadata`
- `Moments_Data`

- Spacecraft_Data

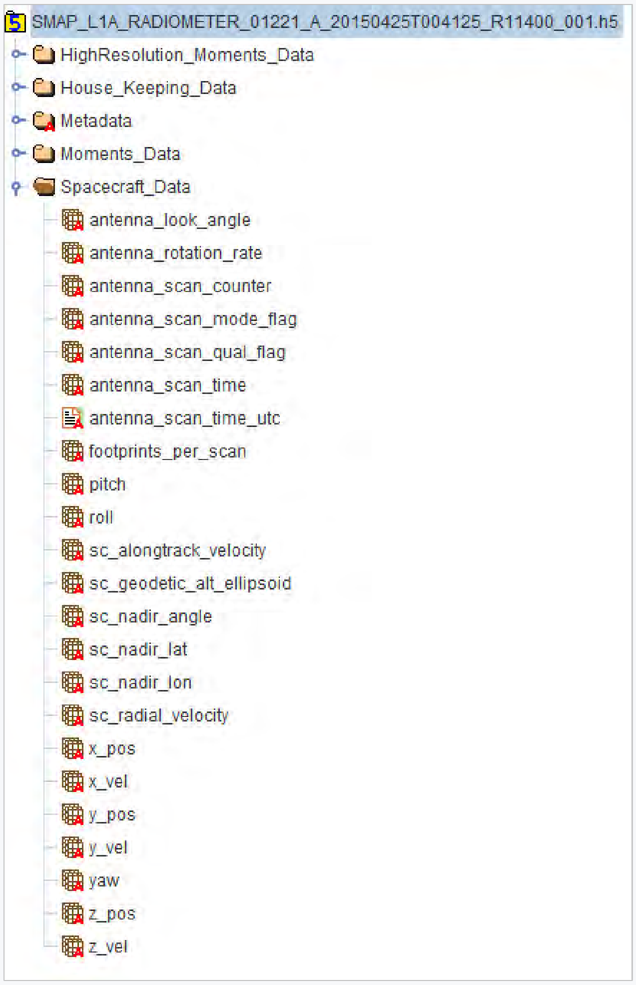

Figure 1. Sample of the HDF5 File Structure

Data Fields Overview

Level-1A radiometer files contain both fullband and subband data, referred to as moments data and high resolution moments data, respectively. Fullband moments data are acquired over the entire 24 MHz radiometer bandwidth, and subband high resolution moments data are acquired for each of the 16 subbands within the 24 MHz bandwidth. Each subband has a 1.5 MHz bandwidth.

Each Level-1A file contains the following:

High Resolution Moments Data

Includes the first four sample raw moments of the 16 subband signals parsed into five radiometric states. The moments are provided for both vertical (V) and horizontal (H) polarizations, and separately expressed in terms of the in-phase (real) and quadrature (imaginary) components of the signals. The complex cross-correlations of the two polarizations are also included for each of the 16 subbands.

Housekeeping Data

Includes housekeeping telemetry or engineering data in both digital numbers and engineering units for each scan.

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.

Moments Data

Includes the first four sample raw moments of the fullband signal parsed into five radiometric states. The moments are provided for both vertical and horizontal polarizations and separately expressed in terms of the in-phase (real) and quadrature (imaginary) components of the signals. Also included are the complex cross-correlations of the two polarizations.

Spacecraft Data

Includes data for an entire antenna scan in the instrument swath, such as geometric and geographic information, spacecraft attitude, spacecraft nadir longitude and latitude, as well as representative time stamps.

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_L1A_RADIOMETER_[Orbit#]_[A/D]_yyyymmddThhmmss_RLVvvv_NNN.[ext]`

For example:

`SMAP_L1A_RADIOMETER_00934_D_201510245T195920_R11920_001.h5`

Where:

Table 1. File Naming Conventions

<table>
<tr><th>Variable</th><th>Description</th></tr>
<tr><td>SMAP</td><td>Indicates SMAP mission data</td></tr>
<tr><td>L1A_RADIOMETER</td><td>Indicates specific product (L1A: Level-1A)</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. Orbit numbers increment each time the spacecraft flies over the southernmost point in the orbit path.</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 time)
D: Descending (where satellite moves from North to South, and 6:00 a.m. is the local solar 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>
<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: R14001 indicates a standard data product with a version of 4.001.</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 Assessment File</td></tr>
<tr><td>.xml</td><td>XML Metadata File</td></tr>
</table></td></tr>
</table>

File Size

Each half-orbit file is approximately 1.4 GB using HDF compression.

Volume

The daily data volume is approximately 36.4 GB.

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. Fullband moments and cross-correlation data are collected globally. High resolution subband moments and cross-correlation data are collected over all land areas and two regions used for calibration—one in the South Pacific Ocean and one in Antarctica. If a portion of the radiometer scan covers land, the entire scan will contain high resolution data, resulting in some ocean coverage near coastal areas.

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.

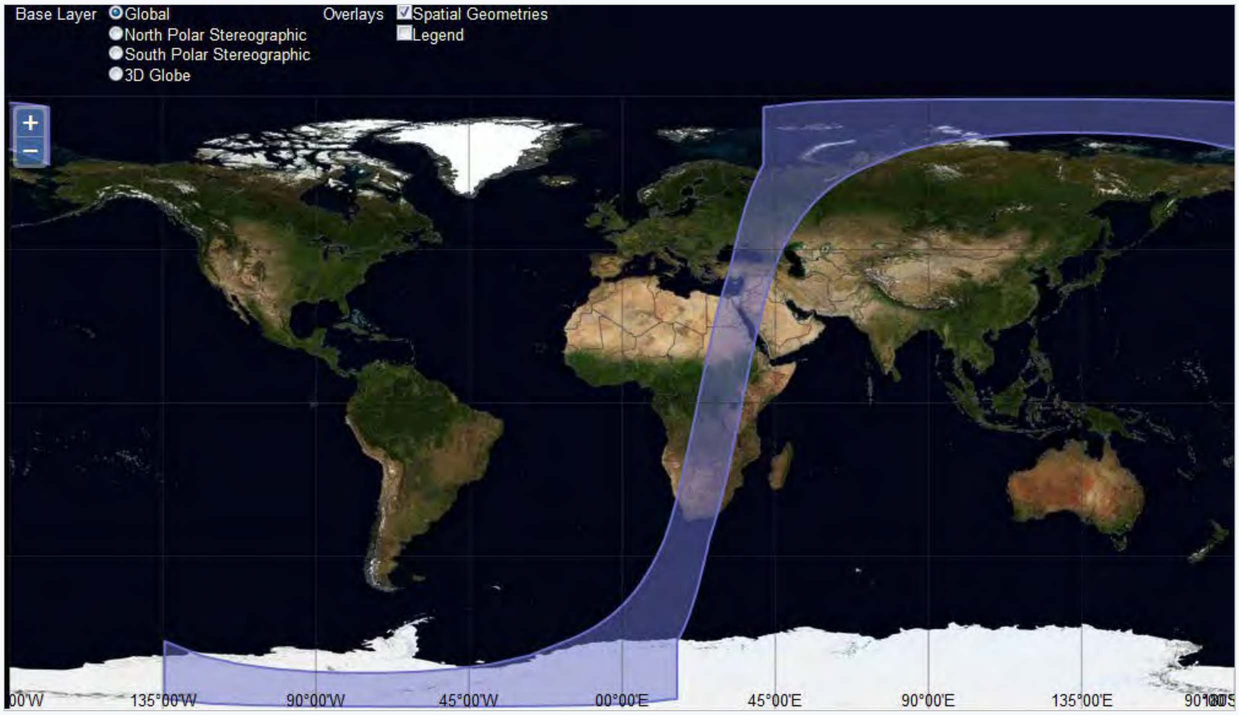

Figure 2. Spatial Coverage Map displaying one descending half orbit of the SMAP L-Band Radiometer. The map was created using Reverb | ECHO.

Spatial Resolution

The native spatial resolution of the radiometer footprint is approximately 40 km.

Temporal Coverage

Data were collected from 31 March 2015 to present.

Temporal Resolution

Each half orbit spans approximately 49 minutes. The data sampling interval is approximately 350 μs for fullband moments data and 1.2 msec for subband high resolution moments data. The subband sampling interval represents a science packet, which covers four Pulse Repetition Intervals (PRIs).

Parameter Description

The Level-1A product includes scaled radiometer counts for the first four statistical moments of the vertically and horizontally polarized signals, as well as the complex cross-correlation between the polarizations. In subsequent processing, the first and second raw moments are used to compute a second central moment, which is the output of a conventional radiometer. The kurtosis is computed using all four raw moments, which is used in Radio Frequency Interference (RFI) detection and mitigation. The complex cross-correlation is used to compute the third and fourth Stokes parameters. All data have an effective 12 bits of resolution and are scaled to single-precision floating point numbers with consistent units.

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.
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

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-1A time-ordered instrument counts are processed from Level-0, Version 1 science packet data.

Processing Steps

Overview

The SMAP Science Data System (SDS) at the Jet Propulsion Laboratory in Pasadena, California generates the Level-1A radiometer product from downlinked radiometer telemetry. Each Level-1A product contains a time-ordered series of instrument counts. These counts are extracted and scaled from instrument packets that conform to Consultative Committee on Space Data Systems (CCSDS) standards. The Level-1A sorts the packets based on the radiometric states, which are described below. Each data set associated with a specific packet of radiometer counts is labeled with a time stamp that records the instant of instrument acquisition. The Level-1A product also contains a set of housekeeping telemetry converted to engineering units for each scan.

The science telemetry includes the first four raw moments of the fullband (24-MHz wide) and 16 subband (each 1.5 MHz wide) signals, for both vertical and horizontal polarization. These data are separately expressed in terms of the in-phase and quadrature components of the signals. The instrument also outputs complex cross-correlation of the two polarizations for the fullband moments data as well as for the moments data that represent the 16 subband/high resolution moments data. Every science data packet therefore contains 360 elements of time-frequency data in high-rate mode and 72 elements of low-rate-mode time data. The subband data provide time and frequency diversity. These data improve detection and mitigation of RFI. Since RFI is expected mostly over land, the SMAP spacecraft downlinks high-rate-mode data over land and low-rate-mode data over oceans.

Radiometer data include science data packets that are generated once every four PRIs. For every PRI of the radar, the radiometer integrates approximately 300 μs within the receive window. The exact integration time varies based on the radar PRI length and blanking time length chosen by the instrument designers. Radiometer packets are made up of four PRIs. Each science data packet includes both fullband moments data and subband high resolution moments data for each of the four PRIs. The subband data are further integrated over each set of four PRIs yielding an integration time of approximately 1.2 ms. The radiometer timing diagram is shown in Figure 3.

Radiometer observation/internal calibration timing

Figure 3. Radiometer Observation/Internal Calibration Timing (Entekhabi, D. et al. 2014)

Radiometric States

The radiometer switching scheme indicates the radiometric state for each particular science data packet. A switch in state can occur once every packet or every four PRIs. The radiometer digital electronics control each instance when the instrument state changes during an antenna scan. The Level-1A processor employs the switching scheme to parse the raw science data. The switches that incorporate the use of the reference load and noise sources are necessary for calibration of science data. The calibration network can produce different combinations of switch and noise diode states. The default radiometer switching sequence produces five states, including:

- **Antenna**
  Data acquired when the radiometer is switched to the antenna to observe the scene.
- **Reference**
  Data acquired when the radiometer is switched to the reference load.
- **Reference with Internal Noise Diode**
  Data acquired when the radiometer is switched to the reference load and the internal noise diode is turned on. The internal noise diode is coupled into both of the V and H channels.
- **Antenna with External Noise Diode**
  Data acquired when an external noise diode is used to inject noise into the radio frequency path.
- **Antenna with Internal Noise Diode**
  Data acquired when the radiometer is switched to the antenna to observe the scene and the internal noise diode is turned on.

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 SMAP L1B Radiometer Time-Ordered Brightness Temperatures, Version 2 to track and enable RFI detection and mitigation.

Level-1A radiometer data can also 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 Level-1A processor uses to flag errors.

Quality Assessment

SMAP data sets provide multiple means to assess quality. Each data set 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 data set.

Each SMAP HDF5 data file contains metadata with Quality Assessment (QA) metadata flags. These QA metadata flags are calculated and set by the Science Data System (SDS) at JPL prior to delivery to the National Snow and Ice Data Center Distributed Active Archive Center (NSIDC DAAC). A separate, ISO 19115-compliant metadata file with an `.xml` file extension is also delivered to NSIDC DAAC with the HDF5 data file; it contains the same information as the 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.

In addition, various levels of QA are conducted with the Level-1A data. If a file passes QA, the SDS applies that file for higher-level processing, browse generation, active science QA, and data archive and distribution. If a file fails QA, the SDS does not send the file to NSIDC DAAC until it is reprocessed and the data are deemed acceptable.

4. References and Related Publications

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. (https://smap.jpl.nasa.gov/files/smap2/SMAP_Handbook_FINAL_1_JULY_2014_Web.pdf, 4.09 MB)

Mohammed-Tano, P. 2015. Soil Moisture Active Passive (SMAP) Project Level 1A Radiometer Product Specification Document. Pasadena, CA USA: SMAP Project, JPL D-92340, Jet Propulsion Laboratory. (http://nsidc.org/data/docs/daac/smap/sp_l1a_p/pdfs/D-92340-A_SMAP_Radiometer_Level1A_Product_Specification_Document_150720_with sigs.pdf, 979 KB)

5. Contacts and Acknowledgments

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