SMAP L4 9 km EASE-Grid Surface and Root Zone Soil Moisture, Version 1

This document describes the SMAP Level-4 Surface and Root Zone Soil Moisture (SPL4SM) data product, which consists of the following collections:

- SMAP L4 9 km EASE-Grid Surface and Root Zone Soil Moisture Geophysical Data (SPL4SMGP)
- SMAP L4 9 km EASE-Grid Surface and Root Zone Soil Moisture Analysis Update (SPL4SMAU)
- SMAP L4 9 km EASE-Grid Surface and Root Zone Soil Moisture Land Model Constants (SPL4SMLM)

For each product, input SMAP L-band brightness temperatures from descending and ascending half-orbit satellite passes (approximately 6:00 a.m. and 6:00 p.m. local solar time, respectively) are assimilated into a land surface model that is gridded using an Earth-fixed, global, cylindrical 9 km Equal-Area Scalable Earth Grid, Version 2.0 (EASE-Grid 2.0) projection.

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

Overview

Platforms	SMAP Observatory NASA Goddard Earth Observing System Model, Version 5 (GEOS-5)
Sensors	SMAP L-Band Radiometer GEOS-5
Spatial Coverage	Global, between 85.044°N and 85.044°S
Spatial Resolution	9 km
Temporal Coverage	31 March 2015 – present
Temporal Resolution	3 hours
Parameters	Soil Moisture
Data Format	Hierarchical Data Format, Version 5 (HDF5)
Metadata Access	View Metadata Records: Geophysical Data Analysis Update Data Land Model Constants
Version	V1. 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	Errors inherited from a variety of input data sources
Get Data	

Geophysical Data	Analysis Update Data	Land Model Constants
FTP HTTPS Reverb | ECHO Worldview Subscription	FTP HTTPS Reverb | ECHO Worldview Subscription	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.

Reichle, R., G. De Lannoy, R. Koster, W. Crow, and J. Kimball. 2015. *SMAP L4 9 km EASE-Grid Surface and Root Zone Soil Moisture Geophysical Data*. Version 1. [Indicate subset used]. Boulder, Colorado USA: NASA National Snow and Ice Data Center Distributed Active Archive Center. doi:http://dx.doi.org/10.5067/HJK4FUNIML52. [Date accessed].

Reichle, R., G. De Lannoy, R. Koster, W. Crow, and J. Kimball. 2015. *SMAP L4 9 km EASE-Grid Surface and Root Zone Soil Moisture Analysis Update*. Version 1. [Indicate subset used]. Boulder, Colorado USA: NASA National Snow and Ice Data Center Distributed Active Archive Center. doi:http://dx.doi.org/10.5067/SHSINYSFEV8L. [Date accessed].

Reichle, R., G. De Lannoy, R. Koster, W. Crow, and J. Kimball. 2015. *SMAP L4 9 km EASE-Grid Surface and Root Zone Soil Moisture Land Model Constants*. Version 1. [Indicate subset used]. Boulder, Colorado USA: NASA National Snow and Ice Data Center Distributed Active Archive Center. doi:http://dx.doi.org/10.5067/ORO7MNBKY525. [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 Figures 1-3, HDF5 files are organized into the following file collections, which contain groups and data sets:

Geophysical Data

- `Geophysical_Data`
- `Metadata`

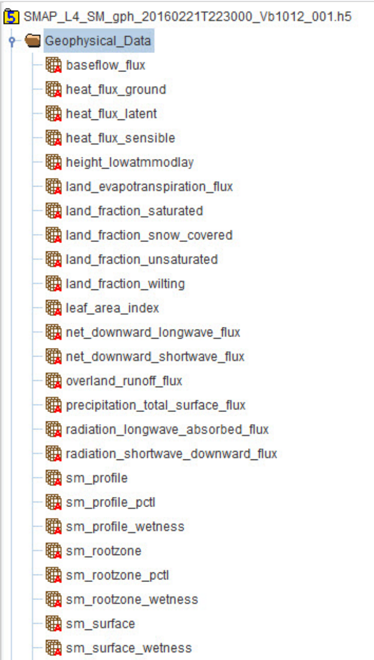

Figure 1. Sample of the HDF5 File Structure

Analysis Update Data

- `Analysis_Data`
- `Forecast_Data`
- `Metadata`
- `Observations_Data`

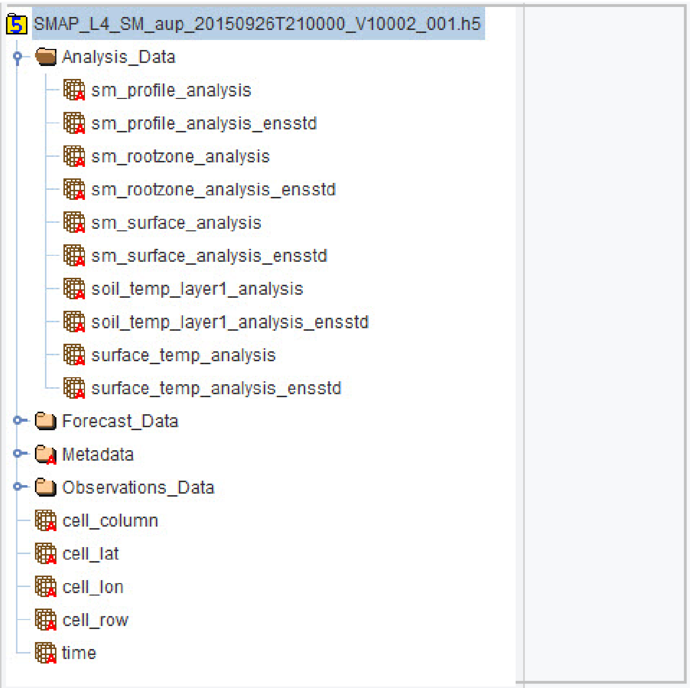

Figure 2. Sample of the HDF5 File Structure

Land Model Constants

- `Land-Model-Constants_Data`
- `Metadata`

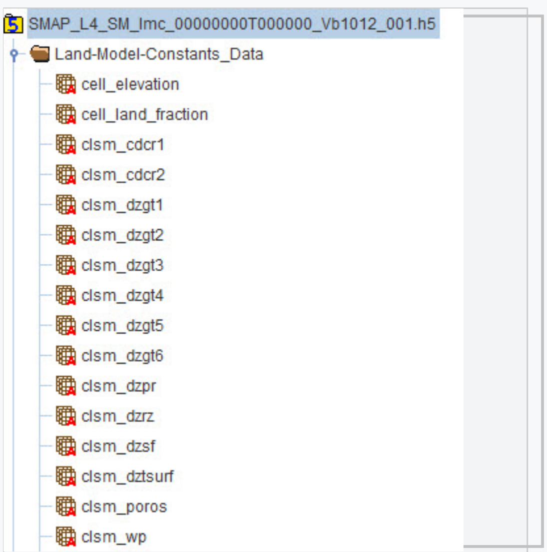

Figure 3. Sample of the HDF5 File Structure

Data Fields Overview

The Level-4 soil moisture product consists of three main collections of data: Geophysical Data, Analysis Update Data, and Land Model Constants. For each 3-hour interval, there are two files: one geophysical (`gph`) file and one analysis update (`aup`) file. The land model constants (`lmc`) collection consists of only one file per product version which is defined by the Science Version ID as described in the File Naming Convention section.

Geophysical Data (gph)

Includes a series of 3-hourly time-averaged geophysical land surface data fields.

Analysis Update Data (aup)

Includes a series of 3-hourly instantaneous/snapshot files that contain assimilated SMAP observations (`Observations_Data` group), corresponding land model predictions (`Forecast_Data` group) and analysis estimates (`Analysis_Data` group), and additional data assimilation diagnostics.

Land Model Constants (lmc)

Includes static land surface model constants that provide further interpretation of the geophysical land surface fields.

Metadata

Each collection also contains metadata that describe the full content of each data file provided in the collection. For a description of all metadata fields for this product, refer to the Metadata Fields document.

Data Fields

Most data element arrays are two dimensional with 1624 rows and 3856 columns. 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_L4_SM_cid_yyyymmddThhmmss_VLMmmm_NNN.[ext]`

For example:

`SMAP_L4_SM_gph_20151015T133000_Vb1010_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>L4_SM</td><td>Indicates specific product (L4: Level-4; SM: Soil Moisture)</td></tr>
<tr><td>cid</td><td>Collection ID (CID), where:
<table>
<tr><th>Variable</th><th>Description of Data</th><th>Description of Date/Time for Collection</th></tr>
<tr><td>gph</td><td>Geophysical Data</td><td>The date/time corresponds to the center point of the 3-hourly time averaging interval. For example, T013000 corresponds to the time average from 00:00:00 UTC to 03:00:00 UTC on a given day.</td></tr>
<tr><td>aup</td><td>Analysis Update Data</td><td>The date/time indicates the time of the analysis update. For example, T030000 indicates an analysis for 03:00:00 UTC on a given day. This analysis would typically assimilate all SMAP data observed between 01:30:00 UTC and 04:30:00 UTC.</td></tr>
<tr><td>lmc</td><td>Land Surface Model Constants</td><td>For the LMC Collection (time-invariant constants), which consists of only one file per product version, the date/time is 00000000T000000.</td></tr>
</table></td></tr>
<tr><td>yyyymmddThhmmss</td><td>Date/time in Universal Coordinated Time (UTC) of the data file, 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>VLMmmm</td><td>Science Version ID, where:
<table>
<tr><th>Variable</th><th>Description</th></tr>
<tr><td>V</td><td>Version</td></tr>
<tr><td>L</td><td>Launch Indicator (b: Beta-quality data)</td></tr>
<tr><td>M</td><td>1-Digit Major Version Number</td></tr>
<tr><td>mmm</td><td>3-Digit Minor Version Number</td></tr>
</table></td></tr>
</table>

	Example: `Vb1010` indicates a Beta-quality product with a version of 1.010.
`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 and Volume

Table 2 provides file sizes and daily volume estimates for each collection.

Table 2. Approximate File Sizes and Total Daily Volume for the SPL4SM Product

Collection	File Size	Total Daily Volume (Compressed)
`gph`	135 MB	1.2 GB
`aup`	86 MB	1.5 GB
`lmc`	36 MB	36 MB
Product Daily Total		**2.73 GB**

Spatial Coverage

Coverage spans from 180°W to 180°E, and from approximately 85.044°N to 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.

Spatial Resolution

The native spatial resolution of the radiometer footprint is approximately 40 km. Data are then assimilated into a land surface model that is gridded using the 9 km EASE-Grid 2.0 projection.

Projection and Grid Description

EASE-Grid 2.0

SMAP Level-4 soil moisture data are provided on the global cylindrical EASE-Grid 2.0 (Brodzik et al. 2012). Each grid cell has a nominal area of approximately 9 x 9 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 4 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.

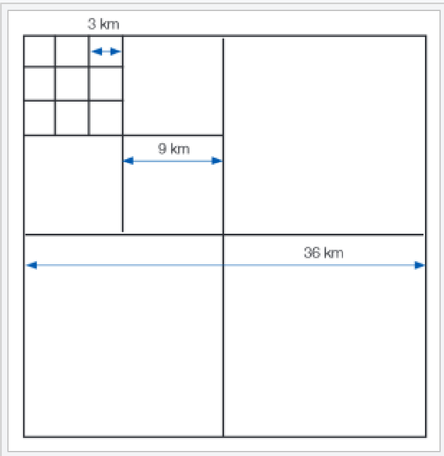

Figure 4. Perfect Nesting in EASE-Grid 2.0

Temporal Coverage

Data were collected from 31 March 2015 through the present.

Temporal Resolution

Three basic time steps are involved in the generation of the Level-4 soil moisture products, including:

1. the land model computational time step (7.5 minutes)
2. the Ensemble Kalman Filter (EnKF) analysis update time step (3 hours), and
3. the reporting/output time step for the instantaneous and time-average geophysical fields that are stored in the data products (3 hours).

SMAP observations are assimilated in an EnKF analysis update step at the nearest 3-hourly analysis time (0z, 3z, ..., and 21z). A broad variety of geophysical parameters are provided as 3-hourly averages between these update times. Moreover, instantaneous forecast and analysis soil moisture and temperature estimates are provided along with the assimilated observations. These snapshots are nominally for 0z, 3z,…, or 21z.

Parameter Description

SMAP Level-4 soil moisture data include the following parameters:

- Surface soil moisture (0-5 cm vertical average)
- Subsurface (root zone) soil moisture (0-100 cm vertical average)
- Additional research products (not validated), including surface meteorological forcing variables, soil temperature, evaporative fraction, net radiation, and error estimates for select output fields that are produced internally by the SPL4SM algorithm. For more details, refer to the Algorithm Theoretical Basis Document (ATBD) for this product.

Soil moisture is output in volumetric units, in wetness (or relative saturation) units, and in percentile units (except surface soil moisture) (Reichle et al. 2014b), permitting a user familiar with the variations of soil moisture in a given applications context to transform the product into application-specific data (Entekhabi et al., 2010). For example, a root zone soil moisture percentile value of 95% for a given time and location corresponds to the 95th percentile of all root zone soil moisture values produced by the land model at that location for a given time of year and across multiple years.

Refer to the Data Fields document for details on all parameters. Parameters are further described in the ATBD for this product under Section 3: Physics of the Problem.

2. Data Access and Tools

Get Data

Data are available via FTP and HTTPS, as listed in Table 3.

Table 3. Get Data Options

Geophysical Data	Analysis Update Data	Land Model Constants
FTP HTTPS	FTP HTTPS	FTP HTTPS

Data are also available through the services listed in Table 4.

Table 4. Data Access Services

Geophysical Data	Analysis Update Data	Land Model Constants	Description
Reverb | ECHO	Reverb | ECHO	Reverb | ECHO	NASA search and order tool for subsetting, reprojecting, and reformatting data.
Worldview	Worldview	N/A	NASA visualization tool for browsing full-resolution imagery and downloading the underlying data.
Subscription	Subscription	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 Reichle et al. (2014a), the ATBD for this product.

Sensor or Instrument Description

For a detailed description of the SMAP instrument, visit the SMAP Instrument page at the JPL SMAP Web site.

Data Sources

SMAP Level-4 soil moisture products are derived from the following data sets:

- SMAP L1C Radiometer Half-Orbit 36 km EASE-Grid Brightness Temperatures, Version 1 (SPL1CTB)*
- SMAP L1C Radiometer Half-Orbit 36 km EASE-Grid Brightness Temperatures, Version 2 (SPL1CTB)*
- GMAO GEOS-5 Forward Processor (FP) Model Data: Daily surface meteorology from observation-constrained global model reanalysis; includes precipitation corrections using the NOAA Climate Prediction Center "Unified" global, 0.5 degree, daily gauge-based data product. (Reichle and Liu, 2014b)

***Note:** This Beta-quality product currently uses both Version 1 and Version 2 Level-1C brightness temperatures as input. To determine the transition date between the two versions, refer to the file-level metadata for each SPL4SM aup granule, which contains a list of the Level-1C brightness temperature files that were used as input.

Theory of Measurements

The primary SMAP measurements, land surface microwave emission at 1.41 GHz and radar backscatter at 1.26 GHz and 1.29 GHz, are directly related to surface soil moisture (in the top 5 cm of the soil column). Several of the key applications targeted by SMAP, however, require knowledge of root zone soil moisture (defined here as soil moisture in the top 1 m of the soil column), which is not directly linked to SMAP observations. The foremost objective of the SMAP Level 4 Surface and Root Zone Soil Moisture (SPL4SM) product is to fill this gap and provide estimates of root zone soil moisture that are informed by and consistent with SMAP observations. Such estimates are obtained by merging SMAP observations with estimates from a land surface model in a soil moisture data assimilation system.

The land surface model component of the assimilation system is driven with observation based surface meteorological forcing data, including precipitation, which is the most important driver for soil moisture. The model also encapsulates knowledge of key land surface processes, including the vertical transfer of soil moisture between the surface and root zone reservoirs. Finally, the model interpolates and extrapolates SMAP observations in time and in space. The SMAP SPL4SM product thus provides a comprehensive and consistent picture of land surface hydrological conditions based on SMAP observations and complementary information from a variety of sources. The assimilation algorithm considers the respective uncertainties of each component and, if properly calibrated, yields a product that is superior to satellite or land model data alone. Error estimates for the SPL4SM product are generated as a by-product of the data assimilation system.

Without root zone soil moisture estimates from the SPL4SM product, SMAP would be of limited use for several key applications targeted by the mission. Fortunately, there has been substantial progress in land data assimilation over the past decade, and soil moisture data assimilation has already been demonstrated successfully with SMAP precursor data sets (refer to section 2.2 of the ATBD). The Global Modeling and Assimilation Office (GMAO) at GSFC currently hosts an ensemble Kalman filter (EnKF) data assimilation system that has been used successfully to assimilate satellite retrievals of surface soil moisture into the NASA Catchment land surface model. When the satellite data, the model data, and the assimilation product are each compared to independent in-situ observations, the assimilated product proves superior (refer to section 2.2 of the ATBD), thereby validating the assimilation system. Most importantly, the assimilation system improves over the model-only root zone soil moisture estimates.

The ATBD for this product provides a detailed description of the SMAP SPL4SM product, its algorithm, and how the product is validated.

Derivation Techniques and Algorithms

This SMAP Level-4 soil moisture product is derived from a variety of data sources. Utilizing the baseline data assimilation algorithm discussed below, input data sources are converted to enhanced estimates of surface soil moisture, root zone soil moisture, and related geophysical variables.

Baseline Algorithm

The SPL4SM science algorithm consists of two key processing elements:

1. GEOS-5 Catchment Land Surface and Microwave Radiative Transfer Model
2. GEOS-5 Ensemble-Based Land Data Assimilation Algorithm

The GEOS-5 Catchment Land Surface and Microwave Radiative Transfer Model is a numerical description of the water and energy transport processes at the land-atmosphere interface, augmented with a model that describes the land surface microwave radiative transfer (refer to section 4.1.1 of the ATBD). The GEOS-5 ensemble-based land data assimilation system (refer to section 4.1.2 of the ATBD) is the tool used to merge SMAP observations with estimates from the land model as it is driven with observation-based surface meteorological forcing data.

The baseline SPL4SM algorithm, described in detail in the ATBD, includes a soil moisture analysis based on the ensemble Kalman filter and a rule-based freeze/thaw analysis. However, data users should note that for the Beta-release version the SPL4SM algorithm ingests only the SPL1CTB radiometer brightness temperatures, contrary to the planned use of downscaled brightness temperatures from the SPL2SMAP product and of landscape freeze-thaw state retrievals from the SPL2SMA product. The latter two products are based on radar observations and are only available for the period from 13 April 2015 through 07 July 2015 due to an anomaly that caused the premature failure of the SMAP L-Band Radar. The decision to use only radiometer SPL1CTB inputs was made to ensure homogeneity in the longer-term SPL4SM Beta-release data record. Eventually downscaled (9 km) brightness temperatures (SPL2SMAP) will be assimilated when and where available, supplemented with 36 km brightness temperature observations from SPL1CTB descending and ascending passes where downscaled data are unavailable. Eventually, freeze/thaw observations will also be assimilated.

After initialization of the system with estimates derived from a model spin-up procedure (refer to section 4.1.3 of the ATBD), the baseline SPL4SM algorithm steps recursively through time, alternating between model forecast (FCST) and analysis (ANA) steps. Figure 4 in the ATBD provides an overview of one forecast and analysis cycle. The algorithm begins with a Catchment model ensemble forecast, initialized with the analysis at time t-1 and valid at time t, labeled FCST(t) in Figure 4 of the ATBD. For each 9 km model grid cell, the forecast freeze/thaw (F/T) state is first compared to the corresponding SMAP freeze/thaw observations (aggregated to the resolution of the model forecast). If the Catchment model forecast and the SMAP observations disagree, the model states in the 9 km grid cell in question are corrected towards the observations in a freeze/thaw analysis (refer to section 4.1.2 of the ATBD). If the forecast and observed freeze/thaw states agree and indicate non-frozen conditions, the grid cell in question is included in a distributed soil moisture analysis (refer to section 4.1.2 of the ATBD). If the model indicates non-frozen conditions and freeze/thaw observations are not available, the grid cell is also included in the soil moisture analysis. Otherwise, the analysis step will be skipped for the grid cell in question. After the analysis has been completed for all grid cells, the algorithm continues with a model forecast to time t+1, and so on.

For more information, refer to the Beta Assessment Report. For an in-depth description of the algorithms, refer to Section 4.1.2: Mathematical Description of the Algorithm in the ATBD for this product.

Ancillary Data

Aside from SMAP observations, the data assimilation system requires initialization, parameter and forcing inputs for the Catchment land surface model, as well as input error parameters for the ensemble-based data assimilation system. These ancillary data requirements are described in detail in the ATBD, Section 4.1.3: Ancillary Data Requirements.

Processing Steps

SMAP Level-4 soil moisture data are generated by the NASA Global Modeling and Assimilation Office (GMAO) located at the NASA Goddard Space Flight Center (GSFC), using the High-End Computing Facilities at the NASA Center for Climate Simulation (NCCS), also located at GSFC in Greenbelt, Maryland.

Inputs

The ancillary input data described in section 4.1.3 of the ATBD are unique to the SPL4SM product and are obtained from the GMAO. The precipitation observations that are used to correct the GMAO precipitation estimates are obtained from the NOAA Climate Prediction Center (Reichle and Liu, 2014). In addition to the ancillary data, SMAP SPL1CTB data are required for the baseline algorithm.

For more information on each portion of the algorithm processing flow, refer to the ATBD.

Error Sources

The data assimilation system weighs the relative errors of the assimilated lower-level product (such as radiance or retrieval) and the land model forecast. Estimates of the error of the assimilation product are dynamically determined as a by-product of this calculation. How useful these error estimates are depends on the accuracy of the input error parameters and needs to be determined through validation; refer to the ATBD, Section 4.2.4. The target accuracy of the assimilated brightness temperatures is discussed in the corresponding ATBDs. Error estimates of the land surface model are discussed in sections 4.13 and 4.1.4 of the ATBD, and required input error parameters are discussed in sections 4.1.2 and 4.1.3e of the ATBD.

Again, each instantaneous land model field automatically comes with a corresponding instantaneous error field which is provided for select variables. The relevant outputs are listed in the Data Fields document for this product. Specifically, the error estimates are derived from the ensemble standard deviation of the analyzed fields. For soil moisture, the ensemble standard deviation is computed from the analysis ensemble in volumetric units (m^3 m^{-3}). For temperatures, the ensemble standard deviation is provided directly in units of Kelvin. These error estimates will vary in space and time.

More information about error sources is provided in the ATBD under Section 4.1.2: Mathematical Description of the Algorithm.

Quality Assessment

These Version 1 Beta data employ preliminary algorithms that are still being validated and are thus subject to uncertainties. Therefore, though data are available beginning 31 March 2015, users who wish to use the highest quality data possible should use data collected on or after 24 April 2015. For in-depth details regarding the quality of these Version 1 Beta data, refer to the Beta Assessment Report.

Quality Overview

SMAP products provide multiple means to assess quality. Each product contains uncertainty measures, and file-level metadata that provide quality information. For information regarding the specific uncertainty measures and file-level metadata contained in this product, refer to the Data Fields document.

Each HDF5 file contains file-level metadata. 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. In addition, a Quality Assessment (QA) file with a .qa file extension is provided for every HDF5 file. QA files contain spatial statistics across the SPL4SM data product, such as the global minimum, mean, and maximum of each data field.

Level-4 surface and root zone soil moisture estimates are validated to a Root Mean Square Error (RMSE) requirement of 0.04 m^3 m^{-3} after removal of the long-term mean bias. This accuracy requirement is identical to Level-2 soil moisture product validation and excludes regions with snow and ice cover, frozen ground, mountainous topography, open water, urban areas, and vegetation with water content greater than 5 kg m^{-2}. Research outputs (not validated) include the surface meteorological forcing fields, land surface fluxes, soil temperature and snow states, runoff, and error estimates that are derived from the ensemble.

Quality Flags

Quality control is also an integral part of the soil moisture assimilation system. At least two kinds of quality control (QC) measures are needed. The first set of QC steps is based on the flags that are provided with the SMAP observations. Only SMAP brightness temperature data that have favorable flags for soil moisture estimation are assimilated, such as acceptable vegetation density, no rain, no snow cover, no frozen ground, no RFI, sufficient distance from open water, etc.

The second set of QC steps are additional rules that exclude SMAP observations from assimilation in the EnKF soil moisture update whenever the land surface model indicates that (1) rain is falling, (2) the soil is frozen, or (3) the ground is fully or partly covered with snow. Note also that the assimilation system will typically provide some weight to the model background and thus buffers the impact of anomalous observations that may slip through the flagging process.

For more information regarding data flags, refer to the Data Fields document.

4. References and Related Publications

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.

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Reichle, R., G. De Lannoy, Q. Liu, A. Colliander, A. Conaty, T. Jackson, J. Kimball, and R. Koster. 2015b. Soil Moisture Active Passive (SMAP) Project Assessment Report for the Beta- Release L4_SM Data Product. Global Modeling and Assimilation Office, Goddard Space Flight Center, Greenbelt, MD, USA. NASA/TM-2015-104606, Vol. 40. (http://nsidc.org/data/docs/daac/smap/sp_l4_sm/pdfs/SMAP_L4_SM_Beta-Release_Assessment_Report_V40.pdf, 5.7 MB)

Reichle, R. et al. 2014a. SMAP Algorithm Theoretical Basis Document: L4 Surface and Root-Zone Soil Moisture Product. SMAP Project, JPL D-66483, Jet Propulsion Laboratory, Pasadena, CA, USA. (http://nsidc.org/data/docs/daac/smap/sp_l4_sm/pdfs/272_L4_SM_RevA_web.pdf, 1.4 MB)

Reichle, R. H., and Q. Liu. 2014b. Observation-Corrected Precipitation Estimates in GEOS-5. SMAP Project, Global Modeling and Assimilation Office, Goddard Space Flight Center, Greenbelt, MD, USA. NASA/TM–2014-104606, Vol. 35. (http://gmao.gsfc.nasa.gov/pubs/docs/Reichle734.pdf, 495 KB).

5. Contacts and Acknowledgments

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