AMSR-E/Aqua L2B Surface Soil Moisture, Ancillary Parms, & QC EASE-Grids, Version 2

USER GUIDE

How to Cite These Data

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

Njoku, E. G. 2004. *AMSR-E/Aqua L2B Surface Soil Moisture, Ancillary Parms, & QC EASE-Grids, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/AMSR-E/AE_LAND.002. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/AE_Land

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

1.1 Format

Level-2B soil moisture data are unique to AMSR-E products. It consists of point data in Hierarchical Data Format - Earth Observing System (HDF-EOS) format where the resulting grid is in a table format rather than a grid that image processing programs can easily visualize. Data types are defined as follows:

- Float64: 64-bit (8-byte) floating-point integer
- Float32: 32-bit (4-byte) floating-point integer
- Int16: 16-bit (2-byte) signed integer

Data files contain core metadata, product-specific attributes, and the data fields described in Table 1. Note: the number of records per granule depends on the number of gridded points over land.

Table 1. Data Field Descriptions

Field Name	Data Type	Description	Scale	Fill Value
Time	Float64	Scan start time in International Atomic Time in seconds with 01 January 1993 00:00:00 as the zero base (TAI93).	n/a	n/a
Latitude	Float32	Latitude (-90.0 to 90.0)	n/a	99 / 98
Longitude	Float32	Longitude (-180.0 to 180.0)	n/a	999 / 998
Row_Index	Int16	EASE-Grid row index (1-586)	n/a	-9999
Column_Index	Int16	EASE-Grid column index (0-1382)	n/a	-9999

Field Name	Data Type	Description	Scale	Fill Value
TB_QC_Flag	Int16	Brightness temperature (T_b) quality control flag. A value of zero indicates the T_b is good for all channels. +/- values indicate the vertical/horizontal polarization is bad for the given channel number (GHz): 89, -89 = bad T_b 89V, 89H 36, -36 = bad T_b 36V, 36H 23, -23 = bad T_b 23V, 23H 18, -18 = bad T_b 18V, 18H 10, -10 = bad T_b 10V, 10H 6, -6 = bad T_b 6V, 6H **Note:** only the first bad channel detected is written to the flag. More than one channel may be bad.	n/a	-9999
Heterogeneity_Index	Int16	As part of the Level-2B processing, a heterogeneity index is computed as the standard deviation of the 36.5H GHz, 11 km resolution data points within each 25 km EASE-Grid cell. The index is used as an output data quality flag. A value of -9999 implies bad T_b data in any channel (TB_QC_Flag).	Multiply data values by 0.01 to obtain units in Kelvins (K).	-9999
Surface_Type	Int16	Indicates surface type classification.	n/a	-9999
Soil_Moisture	Int16	Soil moisture at 10.7 GHz resolution. A value of -9999 indicates no retrieval due to bad T_b data in the retrieval channels (TB_QC_Flag), or screening by land surface classification (Inversion_QC_Flag_1).	Multiply data values by 0.001 to obtain soil moisture in g cm-3. Range: 0 to 500.	-9999

Field Name	Data Type	Description	Scale	Fill Value
Veg_Water_Content	Int16	Vegetation and surface roughness parameter at 10.7 GHz resolution. This term incorporates effects of vegetation and surface roughness together (see "Section | Derivation Techniques and Algorithms."). A value of -9999 indicates no retrieval.	Multiply data values by 0.01 to obtain vegetation water content in kg m-2. Range: 0-1000.	-9999
Land_Surface_Temp	Int16	Land surface temperature is not calculated because of Radio Frequency Interference (RFI) contamination in the 6.9 GHz channels. The field contains only fill values (-9999).	Multiple data values by 0.1 to obtain land surface temperature.	-9999
Inversion_QC_Flag_1	Int16	Inversion quality control flag. Values are as follows: (EA = empirical algorithm; IA = iterative algorithm): 10: Good retrieval, EA 12: Bad retrieval, EA 14: No retrieval 20: Good retrieval, IA 22: Questionable retrieval, IA 24: Bad retrieval, IA 26: No retrieval	n/a	-9999
Inversion_QC_Flag_2	Int16	Not currently used.	n/a	-9999
Inversion_QC_Flag_3	Int16	Not currently used.	n/a	-9999

1.2 Sample Data Record

Figures 1 and 2 show examples of the data fields for Level-2B soil moisture product.

Time	Latitude	Longitude	Row_Index	Column_Index	TB_QC_Flag	Heterogeneity_Index	Surface_Type	Soil_Moisture	Veg_Water_Content
4.5533057...	-81.82574	-79.392624	584	387	0	5983	257	-9999	-9999
4.5533057...	-83.33788	-79.392624	585	387	0	8325	257	-9999	-9999
4.5533057...	-81.82574	-79.132324	584	388	0	128	273	-9999	-9999
4.5533057...	-83.33788	-79.132324	585	388	0	9643	257	-9999	-9999
4.5533057...	-80.551254	-78.87202	583	389	0	8663	273	-9999	-9999
4.5533057...	-81.82574	-78.87202	584	389	0	28	273	-9999	-9999
4.5533057...	-83.33788	-78.87202	585	389	0	10098	257	-9999	-9999
4.5533057...	-80.551254	-78.61172	583	390	0	9997	273	-9999	-9999
4.5533056...	-81.82574	-78.61172	584	390	0	431	257	-9999	-9999
4.5533057...	-83.33788	-78.61172	585	390	0	9048	257	-9999	-9999
4.5533057...	-80.551254	-78.35141	583	391	0	9965	273	-9999	-9999
4.5533056...	-81.82574	-78.35141	584	391	0	41	273	-9999	-9999
4.5533057...	-83.33788	-78.35141	585	391	0	8779	257	-9999	-9999
4.5533057...	-80.551254	-78.09111	583	392	0	8902	273	-9999	-9999
4.5533056...	-81.82574	-78.09111	584	392	0	343	257	-9999	-9999
4.5533057...	-83.33788	-78.09111	585	392	0	8043	257	-9999	-9999
4.5533057...	-80.551254	-77.8308	583	393	0	661	273	-9999	-9999
4.5533056...	-81.82574	-77.8308	584	393	0	502	273	-9999	-9999
4.5533057...	-83.33788	-77.8308	585	393	0	6416	257	-9999	-9999
4.5533057...	-80.551254	-77.5705	583	394	0	373	273	-9999	-9999
4.5533056...	-81.82574	-77.5705	584	394	0	0	273	-9999	-9999
4.5533057...	-83.33788	-77.5705	585	394	0	944	257	-9999	-9999
4.5533056...	-80.551254	-77.3102	583	395	0	547	273	-9999	-9999
4.5533056...	-81.82574	-77.3102	584	395	0	412	273	-9999	-9999

Figure 1. Sample data Fields Table (Cols 1 - 10)

Veg_Water_Content	Land_Surface_Temp	Inversion_QC_Flag_1	Inversion_QC_Flag_2	Inversion_QC_Flag_3
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999
-9999	-9999	14	-9999	-9999

Figure 2. Sample Data Fields Table (Cols 11 - 15)

1.3 File Naming Convention

This section explains the file naming convention used for this product with an example. The date and time correspond to the first scan of the granule.

Example file name:

AMSR_E_L2_Land_T06_200706062353_D.hdf
AMSR_E_L2_Land_X##_yyyymmddhhmm_f.hdf

Tables 2–5 describe the variables in the file naming convention.

Table 2. File Name Variable Descriptions

Variable	Description
X	Product Maturity Code. See Table 3 for key.
##	File version number
yyyy	Four-digit year
mm	Two-digit month
dd	Two-digit day
hh	Hour, listed in UTC time, of first scan in the file
mm	Minute, listed in UTC time, of first scan in the file
f	Orbit direction flag (A = ascending, D = descending)
hdf	HDF-EOS data format

Table 3. Maturity Code Key

Maturity Codes	Description
P	Preliminary - refers to non-standard, near-real-time data available from NSIDC. These data are only available for a limited time until the corresponding standard product is ingested at NSIDC.
B	Beta - indicates a developing algorithm with updates anticipated.
T	Transitional - period between beta and validated where the product is past the beta stage, but not quite ready for validation. This is where the algorithm matures and stabilizes.
V	Validated - products are upgraded to Validated once the algorithm is verified by the algorithm team and validated by the validation teams. Validated products have an associated validation stage. Refer to Table 4 for a description of the stages.

Table 4. Validation Stages

Validation Stage	Description
Stage 1	Product accuracy is estimated using a small number of independent measurements obtained from selected locations, time periods, and ground-truth/field program efforts.
Stage 2	Product accuracy is assessed over a widely distributed set of locations and time periods via several ground-truth and validation efforts.
Stage 3	Product accuracy is assessed, and the uncertainties in the product are well-established via independent measurements made in a systematic and statistically robust way that represents global conditions.

Table 5. File Extension Descriptions

Extensions for Related Files	Description
.jpg	Browse data
.qa	Quality assurance information
.ph	Product history data
.xml	Metadata files

1.4 File Size

A typical half-orbit granule is 0.61 MB. The actual size depends on the number of gridded points over land.

1.5 Spatial Coverage

The following map shows a typical day of coverage (28 half orbits).

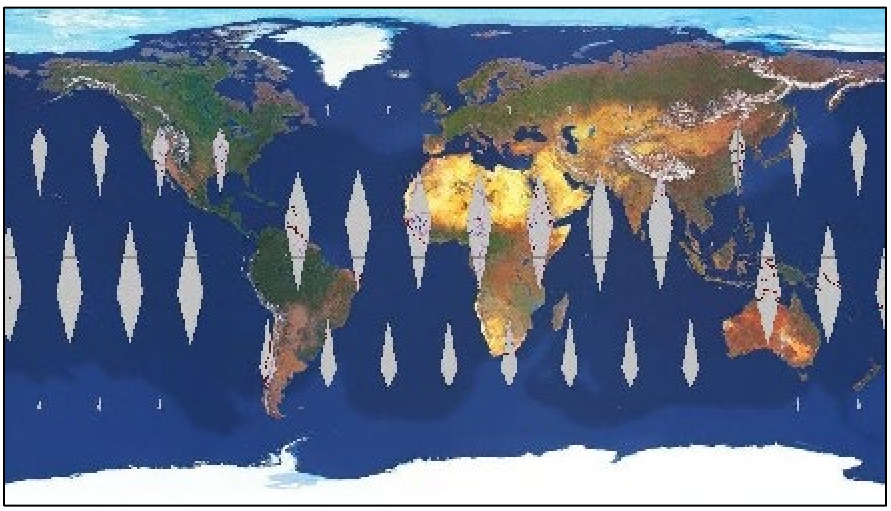

Figure 3. Typical One-Day Spatial Coverage

Coverage is global between 89.24°N and 89.24°S, except for snow-covered and densely-vegetated areas. See AMSR-E Pole Hole for a description of holes that occur at the North and South Poles. The swath width is 1445 km.

1.5.1 Spatial Resolution

Input brightness temperature data at 10.7 GHz, corresponding to a 38 km mean spatial resolution, are resampled to a global cylindrical 25 km EASE-Grid cell spacing. The effective spatial resolution is thus slightly higher than the inherent 38 km resolution.

1.5.2 Projection and Grid Description

Level-2A brightness temperatures are resampled to a global cylindrical EASE-Grid (1383 columns by 586 rows) with a nominal grid spacing of 25 km (true at 30°S). Level-2B data are unique to AMSR-E products. They consist of HDF-EOS point data where the resulting grid is in table format, rather than a grid that image processing programs can easily visualize. In the case of the Level-2B soil data, each geophysical variable value has a corresponding EASE-Grid row and column index.

Please refer to All About EASE-Grid for more information on related products and tools.

1.6 Temporal Coverage

Temporal coverage is from 19 June 2002 to 3 October 2011. See AMSR-E Data Versions for a summary of temporal coverage for different AMSR-E products and algorithms.

1.6.1 Temporal Resolution

Each swath spans approximately 50 minutes. The data sampling interval is 2.6 msec per sample for the 6.9 GHz to 36.5 GHz channels, and 1.3 msec for the 89.0 GHz channel. A full scan takes approximately 1.5 seconds. AMSR-E collects 243 data points per scan for the 6.9 GHz to 36.5 GHz channels, and 486 data points for the 89.0 GHz channel.

The number of satellite overpasses per day at a given location on Earth is a function of latitude (see Figure 4). For example, at the equator AMSR-E does not observe every longitude once per day because successive orbital swaths do not overlap. However, at higher latitudes where orbits do overlap, AMSR-E may observe points on Earth as often as twice per day.

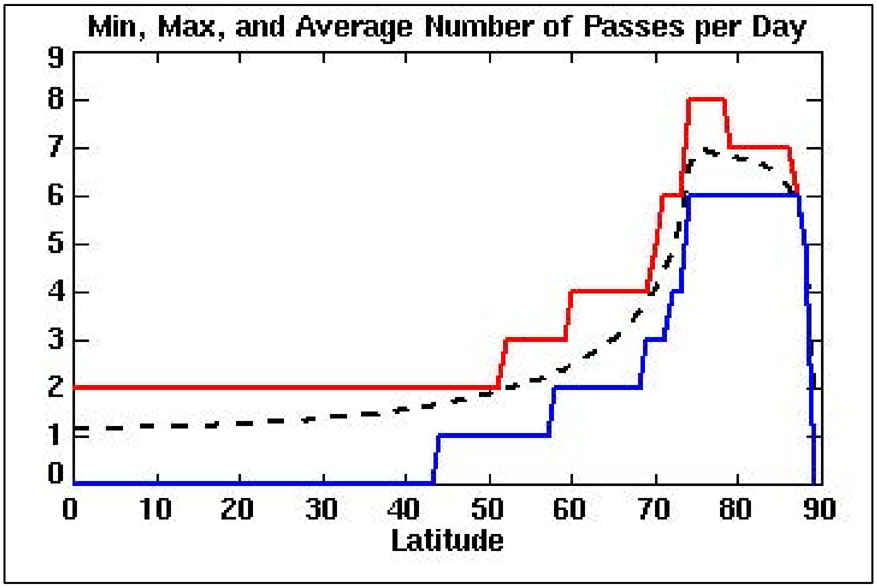

Figure 4. AMSR-E Overpasses Per Day By Latitude

1.7 Parameter or Variable

1.7.1 Surface soil moisture

Soil moisture in the top ~1 cm of soil, averaged over the retrieval footprint and reported in g/cm^3.

Vegetation water content (kg/m^2): equivalent water content (including surface roughness) in the vertical column of vegetation, averaged over the retrieval footprint.

The estimated accuracies of the output variables are:

- Surface soil moisture: 0.06 g/cm^3
- Vegetation/roughness parameter: 0.15 kg/m^2

2 SOFTWARE AND TOOLS

For tools that work with AMSR-E data, see the NSIDC's AMSR-E mission page.

3 DATA ACQUISITION AND PROCESSING

3.1 Data Source

T_b from the AMSR-E/Aqua L2A Global Swath Spatially-Resampled Brightness Temperatures data set are used as input to calculate soil moisture variables. Static input databases are used for surface classification and to identify valid grid points for retrieval.

Surface topography data are derived from the United States Geological Survey (USGS) GTOPO30 global digital elevation model. Horizontal grid spacing is 30 arc seconds. Preprocessing of these data enables screening out points over ocean, mountains, and areas where the topographic variability within a grid cell is likely to degrade geophysical retrievals.

Sand and clay fraction are derived from a 1° x 1° latitude/longitude global soil type database that estimates soil dielectric properties as a function of soil moisture content.

A mask of permanent ice and snow is used to screen out these areas over land.

Vegetation type is derived from the USGS 1 km global land cover characteristics database. These data estimate the dependence of vegetation type on the model coefficient that relates vegetation water content to vegetation opacity.

Finally, precipitable water and surface air temperature are derived from National Center for Environmental Prediction (NCEP) or European Centre for Medium-Range Weather Forecasts (ECMWF) global reanalysis climatologies, or from real-time forecast model outputs. These data are used for estimating atmospheric contributions in the geophysical retrieval algorithm (Njoku 1999).

3.2 Derivation Techniques and Algorithms

The soil moisture algorithm uses Polarization Ratios (PR), which are sometimes called normalized polarization differences of the AMSR-E channel brightness temperatures. PR is the difference between the vertical and horizontal brightness temperatures at a given frequency divided by their sum. This effectively eliminates or reduces surface temperature effects, which is necessary since no dynamic ancillary surface temperature data are input to the algorithm. The algorithm first computes a vegetation/roughness parameter g using PR 10.7 GHz and PR 18.7 GHz, plus three empirical coefficients. Soil moisture is then computed using departures of PR 10.7 GHz from a baseline value, plus four additional coefficients. The baseline values for PR 10.7 GHz are based on monthly minima at each grid cell over an annual cycle.

The vegetation/roughness parameter g incorporates the effects of vegetation and roughness because both have the same functional form (exponential) in their influence on the normalized polarization differences in the retrieval algorithm's simplified model. The parameter g may be interpreted as an equivalent vegetation water content with units of kg m-2. In a desert with no vegetation, any value of g greater than zero is due to roughness only. The value of g reflects the influence of roughness on the polarization ratio as if equivalent vegetation of amount g (kg m-2) were present. If the surface were smooth everywhere, then g would equal the vegetation water content in kg m-2 since the roughness contribution would be zero. Vegetation water content and roughness cannot be determined independently from g, and it is computed primarily as a lumped correction factor for the soil moisture retrieval (Njoku and Chan 2006).

Refer to Njoku et al. (2004) for an assessment of calibration biases over land, and methods used to correct these biases.

3.2.1 Processing Steps

T_b data are resampled to the EASE-Grid using a drop-in-the-bucket method, where all the samples that fall within a grid cell are averaged together. Gridding the data allows brightness temperatures to be combined with ancillary data for classification and retrieval, and allows statistics of brightness temperatures and retrieved variables to be calculated at fixed grid locations from successive orbits.

Surface type classification of gridded brightness temperature identifies and screens grid cells that include major water bodies, dense vegetation, snow, and permanent ice, for which retrievals will not be possible. Other tests are performed, such as for excessive relief, precipitation, frozen ground, and Radio Frequency Interference. However, since the reliability of these tests, as well as their influence on the retrievals, is not well characterized, detection of these conditions does not prevent retrievals from being made and values being written into the output array. The user must decide whether to do further screening on the data based on the surface type flags.

The Surface_Type field in the Level-2B land surface product is a 16-bit integer in which nine possible surface classes are represented by nine individual bits. A bit is assigned with a value of one if the surface class that the bit represents is flagged by the classification subroutine. The sequence begins with the least significant bit, for example, the rightmost bit, in order to keep the resulting word small in decimal values:

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
0	0	0	0	0	0	0	?	?	?	?	?	?	?	?	?

bit 1: Permanent ice sheet
bit 2: Mountainous terrain
bit 3: Snow
bit 4: Frozen ground
bit 5: Precipitation
bit 6: RFI
bit 7: Dense vegetation
bit 8: Moderate vegetation
bit 9: Low vegetation

Surface_Type = (bit 1 * 2^0) + (bit 2 * 2^1) + (bit 3 * 2^2) + (bit 4 * 2^3) + (bit 5 * 2^4) + (bit 6 * 2^5) + (bit 7 * 2^6) + (bit 8 * 2^7) + (bit 9 * 2^8)

For example, if the tests for mountainous terrain, snow, and precipitation were all true and the other tests were all false, the value of Surface_Type would be 0000000000010110 binary, or 22 in decimal.

Finally, Level-2B data are output to HDF-EOS data format. The number of records per granule depends on the number of gridded points over land.

3.2.2 Error Sources

AMSR-E measurements of soil moisture are directly sensitive only to the top 1 cm of soil averaged over approximately 60 km spatial extent. Significant uncertainty may therefore arise when these measurements are compared against point-derived in-situ data, due to differences in sampling depth and spatial extent between satellite and in-situ observations.

Measurements of soil moisture are most accurate in areas of low vegetation. Attenuation from vegetation increases the retrieval error in soil moisture (Njoku et al. 2003). Surface type classification is assigned to indicate low and moderate vegetation, and retrievals are not performed in dense vegetation.

The retrieval algorithm does not explicitly model effects of topography, snow cover, clouds, and precipitation. Other potential error sources include anomalous inputs from bad radiometric data and low-level processing errors. The processing algorithm includes checks to identify these and other anomalies and assign appropriate flags (Njoku 1999).

Soil moisture retrievals represent averages over the horizontal footprint area and vertical sampling depth in the top ~1 cm of soil. The actual sampling depth varies with the amount of moisture in the soil. Soil moisture deeper than ~1 cm below the surface may not be sensed by AMSR-E.

The 6.9 GHz channel is shared with mobile communication services; therefore, retrievals using this frequency are subject to Radio Frequency Interference (RFI), particularly near large urban land areas. The soil moisture algorithm uses the 10.7 GHz channel to alleviate the RFI problem. For more information, see the Derivation Techniques and Algorithms section of this document.

Refer to Njoku et al. (2004) for an assessment of calibration biases over land, and methods used to correct these biases.

3.2.3 Quality Assessment

Each HDF-EOS file contains core metadata with Quality Assessment (QA) metadata flags that are set by the Science Investigator-led Processing System (SIPS) at the Global Hydrology and Climate Center (GHCC) prior to delivery to NSIDC. A separate metadata file in XML format is also delivered to NSIDC with the HDF-EOS file; it contains the same information as the core metadata. Three levels of QA are conducted with the AMSR-E Level-2 and -3 products: automatic, operational, and science QA. 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 granule fails QA, SIPS does not send the granule to NSIDC until it is reprocessed. Level-3 products that fail QA are never delivered to NSIDC (Conway 2002).

3.2.3.1 Automatic QA

Surface type classification screens out invalid grid cells, including major water bodies, permanent ice, dense vegetation, and snow.

Quality control is monitored by convergence or limit checks in the retrieval algorithms. In off-line QC, global fields of soil water content, vegetation water content, and brightness temperature are created by averaging the output Level-2 products onto daily and/or monthly grids. The number of samples, means, and standard deviations are examined for missing data and spatial and temporal coherence.

3.2.3.2 Operational QA

AMSR-E Level-2A data arriving at GHCC are subject to operational QA prior to processing higher-Level-products. Operational QA varies by product, but it typically checks for the following criteria in a given file (Conway 2002):

- File is correctly named and sized
- File contains all expected elements
- File is in the expected format
- Required EOS fields of Time, Latitude, and Longitude are present and populated
- Structural metadata is correct and complete
- The file is not a duplicate
- The HDF-EOS version number is provided in the global attributes
- The correct number of input files were available and processed

3.2.3.3 Science QA

AMSR-E Level-2A data arriving at GHCC are also subject to science QA prior to processing higher-Level-products. If less than 50 percent of a granule's data is good, the science QA flag is marked suspect when the granule is delivered to NSIDC. In the SIPS environment, the science QA includes checking the maximum and minimum variable values, and percent of missing data and out-of-bounds data per variable value. At the Science Computing Facility (SCF), also at GHCC, science QA involves reviewing the operational QA files, generating browse images, and performing the following additional automated QA procedures (Conway 2002):

- Historical data comparisons
- Detection of errors in geolocation
- Verification of calibration data
- Trends in calibration data
- Detection of large scatter among data points that should be consistent

Geolocation errors are corrected during Level-2A processing to prevent processing anomalies such as extended execution times and large percentages of out-of-bounds data in the products derived from Level-2A data.

The Team Lead SIPS (TLSIPS) developed tools for use at SIPS and SCF for inspecting the data granules. These tools generate a QA browse image in Portable Network Graphics (PNG) format and a QA summary report in text format for each data granule. Each browse file shows Level-2A and Level-2B data. These are forwarded from Remote Sensing Systems (RSS) to GHCC along with associated granule information, where they are converted to HDF raster images prior to delivery to NSIDC.

3.2.4 Version History

See AMSR-E Data Versions for a summary of algorithm changes since the start of mission.

3.3 Sensor or Instrument Description

See “NASA | AMSR-E“ for details about the AMSR-E instrument.

4 REFERENCES AND RELATED PUBLICATIONS

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For a list of research studies that have cited AMSR-E data distributed by the NASA NSIDC DAAC, see AMSR-E | Published Research.

5 CONTACTS AND ACKNOWLEDGMENTS

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6 DOCUMENT INFORMATION

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