AMSR-E/Aqua L2B Surface Soil Moisture, Ancillary Parms, & QC EASE-Grids, Version 3

USER GUIDE

How to Cite These Data

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

Chan, S., R. Bindlish, and T. Jackson. 2021. *AMSR-E/Aqua L2B Surface Soil Moisture, Ancillary Parms, & QC EASE-Grids, Version 3*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/3JUPY6PAHHCP. [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 DATA DESCRIPTION

1.1 Parameters

This data set contains gridded estimates of soil moisture (cm^3/cm^3) in the top ~1 cm of soil, averaged over the AMSR-E retrieval footprint. Soil moisture is estimated from AMSR-E/Aqua L2A brightness temperature (T_b) measurements using two different approaches: the Normalized Polarization Difference algorithm (NPD) and the Single Channel Algorithm (SCA).

Ancillary data are also provided to help interpret the soil moisture observations, including vegetation roughness, footprint counts for a variety of ambient surface conditions, and QA flags.

1.2 File Information

1.2.1 Format

AMSR-E Level-2B soil moisture data consist of point data stored in Hierarchical Data Format - Earth Observing System, Version 5 (HDF-EOS5). HDF-EOS5 is a file format and software library that augments standard HDF5 with conventions, data types, and metadata elements specific to NASA EOS mission data.

1.2.2 File Contents

Within HDF-EOS5 data files, similar variables such as science data and file attributes are grouped together. AE_Land Version 3 science data are stored in the variable named “`Combined NPD and SCA Output Fields`” located in “`/HDFEOS/POINTS/AMSR-E Level 2 Land Data/Data/`”:

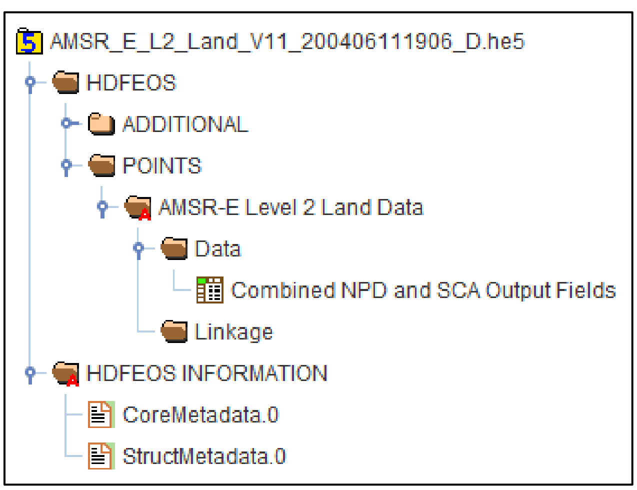

Figure 1. AE_Land V3 Data File Groups (HDFView)

"`Combined NPD and SCA Output Fields`" is structured as a table (as opposed to a 2D array or grid) in which each column is a parameter whose values have one of the following data types:

- Float64: 64-bit (8-byte) floating-point integer
- Float32: 32-bit (4-byte) floating-point integer
- Int32: 32-bit (4-byte) signed integer

Table 1 describes each column in the "`Combined NPD and SCA Output Fields`" data table. Note that columns 21 – 35 contain variables which capture the number of footprints within each grid cell that satisfy a given ambient surface condition. For more information about these variables, see "Section 2.2.3 | Ambient Surface Conditions."

Table 1. Column Names and Descriptions for "Combined NPD and SCA Output Fields"

Col #	Col Title (Parameter Name)	Type	Description	Units	Fill Value
1	Time	Float64	Scan start time in International Atomic Time in seconds with 01 January 1993 00:00:00 as the zero base (TAI93).	Seconds	n/a
2	Latitude	Float32	Latitude of the center of a 25-km EASEv1-Grid cell (-90.0 to 90.0)	degrees	99 / 98
3	Longitude	Float32	Longitude of the center of a 25-km EASEv1-Grid cell (-180.0 to 180.0)	degrees	999 / 998
4	RowIndex	Int32	EASE-Grid row index (1-586)	n/a	-9999
5	ColumnIndex	Int32	EASE-Grid column index (0-1382)	n/a	-9999
6	TBH10r2	Float32	10.7 GHz H-polarized brightness temperature (T_b)	K	-9999
7	TBV10r2	Float32	10.7 GHz V-polarized T_b	K	-9999
8	TBH18r2	Float32	18.7 GHz H-polarized T_b	K	-9999
9	TBV18r2	Float32	18.7 GHz V-polarized T_b	K	-9999
10	TBH23r2	Float32	23.8 GHz H-polarized T_b	K	-9999
11	TBV23r2	Float32	23.8 GHz V-polarized T_b	K	-9999
12	TBH36r2	Float32	36.5 GHz H-polarized T_b	K	-9999
13	TBV36r2	Float32	36.5 GHz V-polarized T_b	K	-9999
14	TBH89r2	Float32	89.0 GHz H-polarized T_b	K	-9999
15	TBV89r2	Float32	89.0 GHz V-polarized T_b	K	-9999
16	VegetationRoughnessNPD	Float32	Vegetation roughness	n/a	-9999

Col #	Col Title (Parameter Name)	Type	Description	Units	Fill Value
17	SoilMoistureNPD	Float32	Soil moisture as determined by the NPD algorithm	cm^3/cm^3	-9999
18	RetrievalQualityFlagNPD	Int32	Value: 0= valid retrieval, 1= invalid retrieval	n/a	-9999
19	SoilMoistureSCA	Float32	Soil moisture as determined by the SCA algorithm, measured in volume fraction of water/soil	cm^3/cm^3	-9999
20	RetrievalQualityFlagSCA	Int32	Value: 0= valid retrieval, 1= invalid retrieval	n/a	-9999
21	FlagCountAllSamples	Int32	Number of T_b footprints	n/a	n/a
22	FlagCountGoodSamples	Int32	Number of good T_b footprints	n/a	n/a
23	FlagCountRFI	Int32	Number of RFI contaminated T_b footprints	n/a	n/a
24	FlagCountInvalidTBRange	Int32	Number of out of range T_b footprints	n/a	n/a
25	FlagCountWater	Int32	Number of T_b footprints over water	n/a	n/a
26	FlagCountIce	Int32	Number of T_b footprints over ice	n/a	n/a
27	FlagCountSnow	Int32	Number of T_b footprints over snow	n/a	n/a
28	FlagCountFrozenGround	Int32	Number of T_b footprints over frozen ground	n/a	n/a
20	FlagCountRain	Int32	Number of T_b footprints over rain	n/a	n/a
30	FlagCountWetland	Int32	Number of T_b footprints over wetland	n/a	n/a
31	FlagCountUrban	Int32	Number of T_b footprints over an urban area	n/a	n/a
32	FlagCountLow2ModerateVWC	Int32	Number of T_b footprints over low to moderate vegetation water content	n/a	n/a
33	FlagCountDenseVWC	Int32	Number of T_b footprints over dense vegetation water content	n/a	n/a
34	FlagCountMissingSoilTexture	Int32	Number of T_b footprints over missing soil texture data	n/a	n/a
35	FlagCountMissingNDVI	Int32	Number of T_b footprints over missing NDVI data	n/a	n/a

HDFEOS core metadata and structural metadata are stored in the `/HDFEOS INFORMATION/` subgroup in the `CoreMetadata.0` and `StructMetadata.0` variables (see Figure 1).

1.2.3 Naming Convention

Example file name:

```
AMSR_E_L2_Land_V11_200406111906_D.he5
AMSR_E_L2_Land_[X][##]_[yyyymmdd][hhmm]_[f].[ext]
```

Tables 2–4 describe the variables in the AE_Land V3 file naming convention.

Table 2. File Name Variable Descriptions

Variable	Description
X	Product Maturity Code. See Table 3 for key.
##	File version number
yyyymmdd	Year, month, and day
hhmm	Hour and minute (UTC) of first scan in file
f	Orbit direction flag (A = ascending, D = descending)
ext	File extension: .he5 (HDF-EOS) .qa (quality assurance) .ph (product history) .jpg (browse image) .xml (science metadata)

Table 3. Maturity Code Key

Maturity Codes	Description
P (preliminary)	Non-standard, near-real-time data. These data are only available until the corresponding standard product is ingested.
B (beta)	Developing algorithm with updates anticipated.
T (transitional)	Beyond beta, but not quite ready for validation.
V (validated)	Products are upgraded to validated once the algorithm has been verified by the algorithm team. Validated products have an associated validation stage (see Table 4).

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.

1.3 Spatial Information

1.3.1 Coverage

Coverage is global between 89.24° N and 89.24° S. For an explanation of the coverage gap poleward of 89.24° (the “Pole Hole”), see the Appendix.

The following map shows a typical day’s coverage for the AMSR-E instrument (28 half orbits).

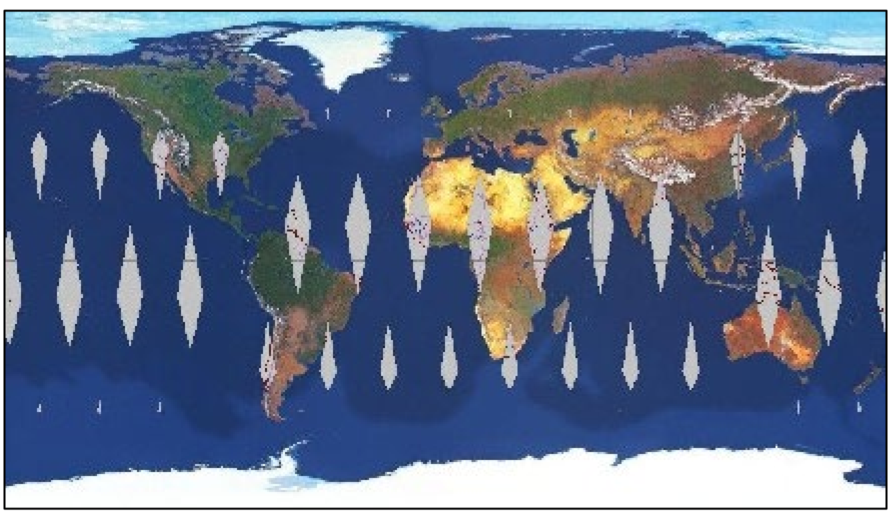

Figure 2. Typical AMSR-E One-Day Spatial Coverage

1.3.2 Resolution

25 km

Input T_b with a mean, 38 km spatial resolution are resampled to a global cylindrical 25 km EASE-Grid. Thus, the effective spatial resolution is slightly higher than the inherent 38 km resolution.

1.3.3 Geolocation

The following tables provide information for geolocating this data set

Table 5. Geolocation Details

Geographic coordinate system	Unspecified datum based upon the International 1924 Authalic Sphere
Projected coordinate system	NSIDC EASE-Grid Global
Longitude of true origin	0°
Latitude of true origin	30° S
Scale factor at longitude of true origin	N/A
Datum	Unspecified datum based upon the International 1924 Authalic Sphere
Ellipsoid/spheroid	International 1924 Authalic Sphere
Units	meters
False easting	0
False northing	0
EPSG code	3410
PROJ4 string	+proj=cea +lon_0=0 +lat_ts=30 +x_0=0 +y_0=0 +a=6371228 +b=6371228 +units=m +no_defs
Reference	http://epsg.io/3410

Table 6. Grid Details

Grid cell size (x, y pixel dimensions)	25,067.53 m (x) 25,067.53 m (y)
Number of rows	586
Number of columns	1383
Geolocated lower left point in grid	85.044° S, 180.000° W
Nominal gridded resolution	25 km x 25 km
Grid rotation	N/A
ulxmap – x-axis map coordinate of the outer edge of the upper-left pixel	-17334193.54
ulymap – y-axis map coordinate of the outer edge of the upper-left pixel	7344784.83

For more information about the Ease-Grids, see "What are the EASE Grids?"

1.4 Temporal Information

1.4.1 Coverage

Temporal coverage is from 01 June 2002 (see note below) to 04 October 2011.

Note: For Version 3, the Science Team re-evaluated the quality of AMSR-E Land data from 01 June to 18 June 2002 (the start date for previous versions) and concluded that at least some good science data exists for all days.

In detail:

- The first 19 files for June 1 are unusable (fill value -9999);
- The 20th file on June 1 (200606011546_A) contains 85%–88% bad data;
- The 21st file on June 1 through the last file on June 18 all contain at least 25% good data.

See AMSR-E Data Versions for a summary of temporal coverage for different AMSR-E products and algorithms.

1.4.2 Resolution

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 did not observe every longitude once per day because successive orbital swaths did not overlap. However, at higher latitudes where orbits do overlap, AMSR-E observed points on Earth as often as twice per day.

Each data file spans approximately 50 minutes. The instrument sampling interval is 2.6 ms for the 6.9 GHz to 36.5 GHz channels and 1.3 ms for the 89.0 GHz channel. A full scan of the AMSR-E instrument took approximately 1.5 seconds and collected 243 data points for the 6.9 GHz to 36.5 GHz channels and 486 data points for the 89.0 GHz channel.

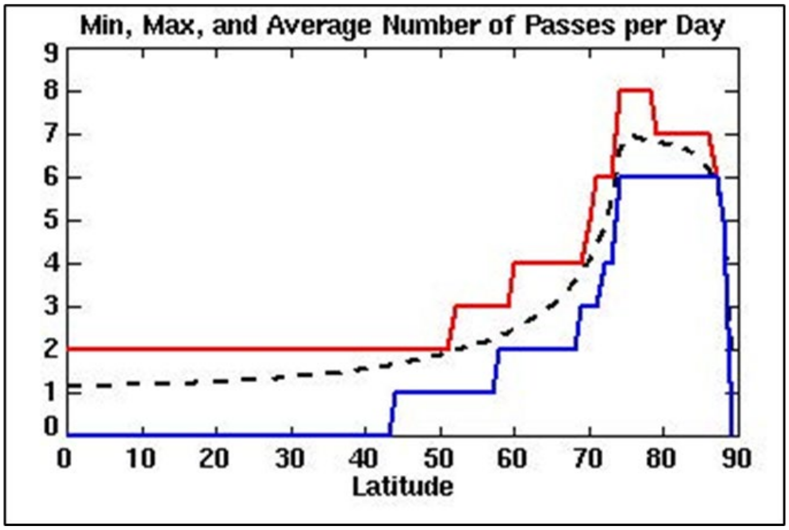

Figure 3. AMSR-E Overpasses Per Day By Latitude

2 DATA ACQUISITION AND PROCESSING

2.1 Acquisition

Soil moisture is computed from T_b observations in the AMSR-E/Aqua L2A Global Swath Spatially-Resampled Brightness Temperatures (AE_L2A) data set.

Static databases are used to classify certain surface types and identify valid grid points for soil moisture retrieval. Major water bodies and land with snow and permanent ice cover are masked out, and soil moisture is not computed for areas with dense vegetation and active precipitation, as reliable estimates cannot be produced for these conditions.

Additional tests are performed to locate excessive relief, frozen ground, and radio frequency interference (RFI); however, because the reliability of these tests and their influence on soil moisture retrieval is not well characterized, soil moisture estimates are calculated and written to the output array so that users can choose whether to further screen the data based on surface type flags.

Surface topography is determined from the United States Geological Survey (USGS) GTOPO30 global digital elevation model, which has a horizontal grid spacing of 30 arc seconds. Topography data are used to screen out points over inland water, mountains, and areas where the topographic variability within a grid cell is likely to degrade retrievals.

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.

Precipitable water and surface air temperature are obtained from National Center for Environmental Prediction (NCEP) and European Centre for Medium-Range Weather Forecasts (ECMWF) global reanalysis climatologies, or from real-time forecast model outputs. These data are used to estimate and remove atmospheric effects.

Finally, sand and clay fractions are derived from a 1° x 1° global soil type database that estimates soil dielectric properties as a function of soil moisture content.

2.2 Processing

New for Version 3, this data set estimates soil moisture following the approach utilized for the AMSR-E/AMSR2 Unified L2B Half-Orbit 25 km EASE-Grid Surface Soil Moisture (AU_Land) product. Soil moisture is computed using two different algorithms: the Normalized Polarization Difference (NPD) algorithm and the first standard Single Channel Algorithm (SCA). Both algorithms use X-band observations due to RFI observed in the C-band.

For more information regarding these two algorithms, please see "AMSR2 Global Soil Moisture Retrievals Using the Normalized Polarization Difference (NPD) Algorithm and Single Channel Algorithm (SCA)" (AMSR2 Soil Moisture ATBD).

2.2.1 NPD Algorithm

The foundation of the NPD algorithm is the Microwave Polarization Difference Index (MPDI), the normalized difference between the vertically and horizontally polarized T_b at a given frequency defined as follows:

$$MPDI = (T_{bV} - T_{bH}) / (T_{bV} + T_{bH})$$

The MPDI can be approximated in a form that is independent of surface temperature and has soil moisture and vegetation dependencies that are separable. For a more detailed explanation, see Njoku and Chan (2006) and the AMSR2 Soil Moisture ATBD. For an assessment of calibration biases over land and methods used to correct them, see Njoku et al. (2004).

2.2.2 SCA Algorithm

The SCA approach uses horizontally polarized T_b observations from the lowest frequency channel available—in this case, 10.7 GHz—due to its highest sensitivity to soil moisture observations. The SCA approach is based on the simplified radiative transfer model developed under the assumption of minimal atmospheric contribution and equal canopy and soil temperature (Jackson, 1993). The SCA is applied to the individual L2 AMSR-E footprint T_b observations to produce a swath-based time-order product.

In the SCA approach, T_b is converted to emissivity using a surrogate for the effective physical temperature of the emitting layer. The derived emissivity is corrected for vegetation and surface roughness to obtain the smooth soil emissivity. At this point, the Fresnel equation is used to determine the dielectric constant of the soil-water mixture. As a last step, the AMSR-E SCA uses the Wang and Schmugge (1980) dielectric mixing model to estimate soil moisture.

For more detailed information, refer to the AMSR2 Soil Moisture ATBD.

2.2.3 Ambient Surface Conditions

“FlagCount” variables (e.g., FlagCountWater, FlagCountIce, FlagCountSnow, etc.) record the number of AMSR-E footprints within a grid cell that satisfy a given ambient surface condition. Because most of these surface conditions are unfavorable for estimating soil moisture, higher counts correspond to lower confidence in the quality of the estimate.

The algorithm first determines the total number of footprints within each grid cell and stores it in FlagCountAllSamples. It then conducts tests to determine how many of the footprints in each cell match the criterion for a given surface condition and stores the count in the following variables:

- **FlagCountRFI**: Number of footprints contaminated by radio frequency interference (RFI), defined as 10.7V - 18.7V ≥ 10 K.
- **FlagCountInvalidTBRange**: Number of footprints whose min/max exceed 60K and 320K, respectively. Counts are computed for all four channels used to estimate soil moisture (10.7H, 10.7V, 18.7H, 18.7V) and the only highest number is reported.
- **FlagCountWater**: Number of footprints over water, according to a static mask derived from the MODIS/Terra Land Water Mask (MOD44W) product.
- **FlagCountIce**: Number of footprints over permanent ice, according to a multiyear, static land cover classification map derived from the MODIS Land Cover Type (MCD12Q1) product.
- **FlagCountSnow**: Number of footprints over snow-covered surface. Binary, snow/no snow decisions are determined from threshold relationships using H and V polarizations of the 18.7 GHz, 23.8 GHz, 36.5 GHz, and 89.0 GHz channels.
- **FlagCountFrozenGround**: Number of footprints with inferred soil temperature < 273.15 K (0° C). Inferred soil temperature is computed from the 36.5V channel using a regression relationship.
- **FlagCountRain**: Number of footprints with active rainfall. Binary rainfall/no rainfall decisions are determined from threshold relationships using 89.0V and 18H and 18V channels.
- **FlagCountWetland**: Number of footprints over wetlands, according to a multiyear, static land cover classification map derived from the MODIS Land Cover Type (MCD12Q1) product.
- **FlagCountUrban**: The number of footprints over urban areas,according to a multiyear, static land cover classification map derived from the MODIS Land Cover Type (MCD12Q1) product.

- **FlagCountDenseVWC**: Number of footprints over vegetation with a vegetation water content (VWC) > 5.0 kg/m^2.
- **FlagCountMissingSoilTexture**: Number of footprints over a location with no soil texture information in Harmonized World Soil Database - Texture*.
- **FlagCountMissingNDVI**: Number of footprints over a location with no Normalized Difference Vegetation Index (NDVI) information in the MODIS/Terra Vegetation Indices (MOD13A) product.
- **FlagCountLow2ModerateVWC**: The number of footprints over vegetation with vegetation water content (VWC) of 0 < VWC < 1.5 kg/m^2.

Finally, the **FlagCountGoodSamples** variable contains the number of footprints in the cell that have not been flagged by any of the criteria above, i.e., the number of footprints with favorable conditions for estimating soil moisture.

*The Harmonized World Soil Database is maintained by the Food and Agriculture Organization (FAO) of the United Nations.

2.3 Errors, Limitations, and Quality

2.3.1 Error Sources

AMSR-E soil moisture measurements are directly sensitive only to the top 1 cm of soil averaged over approximately 60 km spatial extent. The actual sampling depth varies with the amount of moisture in the soil. 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 due to vegetation increases the retrieval error in soil moisture (Njoku et al. 2003). Surface type classifications are assigned to indicate low and moderate vegetation, and retrievals are not performed in dense vegetation.

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.

Lastly, the 6.9 GHz channel is shared with mobile communication services; therefore, retrievals using this frequency are subject to RFI, particularly near large urban land areas. The soil moisture algorithm uses the 10.7 GHz channel to alleviate RFI.

2.3.2 Limitations

Soil moisture retrievals are not computed over open water (oceans and other water bodies), frozen ground, snow and/or ice covered land, dense vegetation, and when active precipitation is present.

2.3.3 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).

2.3.3.1 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.

2.3.3.2 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

2.3.3.3 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.

See AMSR-E Validation Data for information about the data used to check the accuracy and precision of AMSR-E observations.

2.4 Instrumentation

For a detailed description of the AMSR-E instrument, see NASA’s AMSR-E page.

3 SOFTWARE AND TOOLS

For tools that work with AMSR-E data, see “Tools” on the AMSR-E project page. For tools that work with HDF-EOS data, see the HDF-EOS Tools and Information Center website.

4 VERSION HISTORY

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

5 CONTACTS AND ACKNOWLEDGMENTS

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To see research articles using AMSR-E data, see AMSR-E/Aqua Data Published Research.

7 DOCUMENT INFORMATION

7.1 Publication Date

April 2021

7.2 Date Last Updated

April 2021

APPENDIX – AMSR-E POLE HOLE

In the image below, the Aqua satellite travels along the dashed line marking the center of scan. When that center point reaches its maximum latitude, the ascending half orbit (green dots) ends, and a new descending half orbit (orange) starts. All orbits will be split at this same latitude, all the ascending orbits will reach the same maximum latitude, and all the descending orbits will reach a different (and higher) maximum latitude. This creates "pole holes" with different radii. The South Pole is similar, except that ascending and descending are swapped.

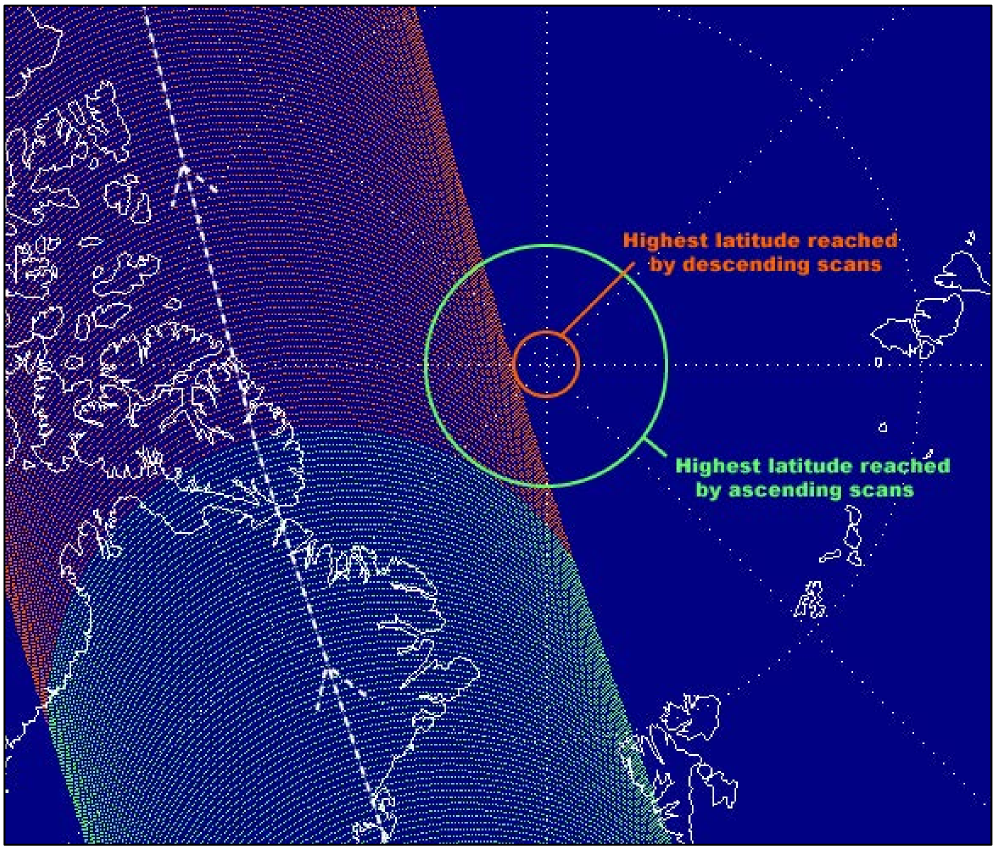

Figure A - 1. AMSR-E Pole Hole