AMSR-E/Aqua L3 Global Snow Water Equivalent EASE-Grids, Version 2

USER GUIDE

How to Cite These Data

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

Tedesco, M., R. Kelly, J. L. Foster, and A. T. Chang. 2004. *AMSR-E/Aqua Daily L3 Global Snow Water Equivalent 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_DYSNO.002.

Tedesco, M., R. Kelly, J. L. Foster, and A. T. Chang. 2004. *AMSR-E/Aqua 5-Day L3 Global Snow Water Equivalent 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_5DSNO.002. [Date Accessed].

Tedesco, M., R. Kelly, J. L. Foster, and A. T. Chang. 2004. *AMSR-E/Aqua Monthly L3 Global Snow Water Equivalent EASE-Grids, Version 2*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Center. https://doi.org/10.5067/AMSR-E/AE_MOSNO.002. [Date Accessed].

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

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/AE_DYSNO, https://nsidc.org/data/AE_5dSNO, https://nsidc.org/data/AE_MOSNO

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These Level-3 Snow Water Equivalent (SWE) data sets contain SWE data and quality assurance flags mapped to N. and S. Hemisphere 25 km Equal-Area Scalable Earth Grids (EASE-Grids).

This user guide applies to the following AMSR-E data sets:

AE_DySno (AMSR-E/Aqua Daily L3 Global Snow Water Equivalent EASE-Grids)

AE_5Dsno (AMSR-E/Aqua 5-Day L3 Global Snow Water Equivalent EASE-Grids)

AE_MoSno (AMSR-E/Aqua Monthly L3 Global Snow Water Equivalent EASE-Grids)

1 DETAILED DATA DESCRIPTION

1.1 Format

Data are stored in Hierarchical Data Format - Earth Observing System (HDF-EOS) format. Files contain core metadata, product-specific attributes, and 721 rows x 721 columns pixel data fields in 1-byte unsigned integer format. Table 1 through Table 3 describe the data fields and the pixel values for the SWE and QA flags.

Table 1. Data Fields

Daily	5-day	Monthly
SWE_NorthernDaily	SWE_NorthernPentad	SWE_NorthernMonth
Flags_NorthernDaily	Flags_NorthernPentad	Flags_NorthernMonth
SWE_SouthernDaily	SWE_SouthernPentad	SWE_SouthernMonth
Flags_SouthernDaily	Flags_SouthernPentad	Flags_SouthernMonth

Note: SWE values are scaled down by a factor of 2 when stored in the HDF-EOS file (0-240). Users must multiply the values by 2 to scale the data up to the correct range of 0-480 mm.

Table 2. Pixel Values for SWE Fields

Value	Description
0-240	SWE divided by 2 (mm)
247	incorrect spacecraft attitude
248	off-earth
252	land or snow impossible
253	ice sheet
254	water
255	missing

Table 3. Pixel Values for QA Flag Fields

Value	Description
241	non-validated
248	off-earth
252	land or snow impossible
253	ice sheet
254	water
255	missing

1.2 File Naming Convention

This section explains the file naming convention used for this product with an example. The date in the file name corresponds to the first scan of the granule.

Example File Names:

```
AMSR_E_L3_DailySnow_B02_20020619.hdf
AMSR_E_L3_5DaySnow_B02_20040705.hdf
AMSR_E_L3_MonthlySnow_B07_200804.hdf
```

Example File Names Using Variables:

```
AMSR_E_L3_DailySnow_X##_yyyymmdd.hdf
AMSR_E_L3_5DaySnow_X##_yyyymmdd.hdf
AMSR_E_L3_MonthlySnow_X##_yyyymm.hdf
```

Note: Refer to Table 4 for the values of the file name variables listed above.

Table 4. Variable Values for the File Name

Variable	Description
X	Product Maturity Code (Refer to Table 5 for valid values.)
##	file version number
yyyy	four-digit year
mm	two-digit month
dd	two-digit day
hdf	HDF-EOS data format

Table 5. Variable Values for the Product Maturity Code

Variable	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 6 for a description of the stages.

Table 6. 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 7 provides examples of file name extensions for related files that further describe or supplement data files.

Table 7. Related File Extensions and Descriptions

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

1.3 File Size

Each daily, 5-day, and monthly granule is 2.1 MB.

1.4 Spatial Coverage

SWE data are available for the full Northern and Southern Hemispheres.

1.4.1 Spatial Resolution

Spatial resolution is 25 km.

1.4.2 Projection and Grid Description

Data are provided in Northern and Southern Hemisphere EASE-Grid projections. For details, please see NSIDC's EASE-Grid: A Versatile Set of Equal-Area Projections and Grids Web page.

Grids are 721 rows x 721 columns. For more information, including details about the EASE-Grid projections plus related products and tools, see NSIDC's All About EASE-Grid Web site.

For this EASE-Grid product, the tar files `Nl_geolocation.tar.gz` and `Sl_geolocation.tar.gz` contain geolocation tools. These tools include map projection parameters (.mpp files), grid parameter definitions (.gpd files), latitude/longitude binary files, and conversion software such as C, FORTRAN (FORmula TRANslation), and IDL (Interactive Data Language). These tar files are available via FTP.

1.5 Temporal Information

AE_DySno: 19 June 2002 to 3 Oct 2011
AE_5Dsno: 19 June 2002 to 3 Oct 2011
AE_MoSno: 19 June 2002 to 1 Oct 2011

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

1.5.1 Temporal Resolution

Daily, 5-day maximum, and monthly mean SWE are available. During leap years, the last 5-day period of February actually has six days.

1.6 Parameter or Variable

Snow Water Equivalent (SWE)

2 SOFTWARE AND TOOLS

For tools that work with AMSR-E data, see Tools on the AMSR-E project page.

3 DATA ACQUISITION AND PROCESSING

3.1 Theory of Measurements

Space-borne sensors measure microwave brightness temperatures from radiation released from the underlying surface, the snowpack, and the atmosphere. The atmospheric contribution is usually small; thus, it does not need to be considered when measuring snowpack parameters over snow covered areas. Snow crystals are effective scatterers of microwave radiation. The deeper the snowpack, the more snow crystals there are available to scatter microwave energy away from the sensor. Hence, microwave brightness temperatures are generally lower for deep snowpacks (more scatterers) than they are for shallow snowpacks (fewer scatterers) (Matzler 1987) and (Foster et al. 1991). Based on this fact, SWE retrieval algorithms were developed (Kunzi et al. 1982), (Chang et al.1982), (Hallikainen and Jolma 1986), (Goodison et al. 1990), and (Rott et al.1991).

The intensity of microwave radiation emitted from a snowpack is determined through radiative transfer computation based on the physical temperature, grain size, density, and underlying conditions of the snowpack. Several factors affect the microwave brightness temperature emitted from a snowpack, including the freeze/thaw states of the underlying soil, crystal size, temperature and density profiles, and the layering structure (Chang and Rango 2000).

3.2 Sensor or Instrument Description

See NSIDC's Instrument Description: Advanced Microwave Scanning Radiometer (AMSR-E) for information about the AMSR-E instrument.

3.3 Data Acquisition Methods

See NSIDC's Instrument Description: Advanced Microwave Scanning Radiometer (AMSR-E) for more information.

3.4 Data Source

The original data source is the AMSR-E/Aqua L2A Global Swath Spatially-Resampled Brightness Temperatures data set.

3.5 Derivation Techniques and Algorithms

The original baseline SWE algorithm is based on methods described in Chang, Foster, and Hall (1987) and Chang et al. (1997). This algorithm identifies land regions that are historically affected by snow; it retrieves the SWE using the simple brightness temperature difference approach described in Chang, Foster, and Hall (1987). Enhancements have been made to the original baseline algorithm including improved SWE retrieval methods (Kelly and Foster 2005) and (Kelly, Foster, and Hall 2005), and advancements will continue with ongoing algorithm updates.

3.5.1 Ancillary Data

Ancillary data is used for:

- Forest attenuation correction (fractional forest cover and forest density)
- Snow density
- Possibility of snow from Dewey and Heim (1981)
- Land/ocean/ice mask to discriminate oceans, land, and ice sheet

Two high spatial resolution MODIS land data sets are used to correct for forest attenuation:

- The 1/120th degree (1 km) MODIS/Terra Land Cover Type 96-Day L3 Global (MOD12Q1) data set is used for fractional forest cover. These data are projected to geographic coordinates.
- The 1/120th degree 500 m MODIS Vegetation Continuous Fields (VCF) (GLCF_MODIS_VCF) data set is used for an estimate of forest density (Hansen et al. 2003). These data are projected to geographic coordinates.

A fractional forest cover ancillary file is derived from the original International Geosphere-Biosphere Programme (IGBP) classification, where each data point is the forest fraction of 0 -100 percent. For each ~1 km pixel, forest fraction in percent is obtained and a matching forest density is found. Both 1 km forest estimated variables (fraction and density) are circular smoothed to a 15 km diameter and regridded to a global 1 km.

A 25 km EASE-grid snow density climatology file for Northern and Southern Hemisphere is derived using the average snow density values for January through March from Canadian and Former Soviet Union ground measurements described in Brown (1998) and Krenke (2004). Average density values are calculated within each of the six classes (Sturm et al. 1995).

The possibility of snow mask and the land/ocean/ice mask are gridded to the 25 km EASE-Grid domain. The land/ocean/ice mask is based on the MOD12Q1 data set.

The retrievals are performed at the Instantaneous Field of View (IFOV) 1 km grid cell and then projected in an EASE-Grid cell. The number of IFOVs that contribute to each EASE-Grid cell is tracked, and an average value of all contributing retrievals is computed for the EASE-Grid cell.

3.5.2 Daily SWE Retrieval

SWE retrievals are performed using AMSR-E/Aqua L2A Global Swath Spatially-Resampled Brightness Temperature un-resampled data. For each low frequency (< 89 GHz) sample, a Snow Depth (SD) retrieval is performed using brightness temperatures at the IFOV and then projected to the 25 km EASE-Grid projection.

The probability of snow per pixel is determined using snow cover maps from Dewey and Heim (1981) and the land/ocean/ice mask. If snow is impossible for a given pixel, the algorithm flags the pixel as no snow and continues to the next pixel. If snow is possible, a snow detection algorithm is applied to the pixel.

In pixels where snow is possible, brightness temperatures are screened. The algorithm uses data from various low frequency channels and a land surface temperature estimator from Kelly et al. (2003) to detect snow. Detection of snow is determined by the thresholds:

$T_b 36V \leq 255$ K

T_b 36H > ≤ 245 K

If these conditions are satisfied, the brightness temperatures for different channels are checked to determine if snow is likely to be shallow or medium-to-deep.

Retrievals are calibrated for snow depth and projected in the 25 km EASE-Grid array. The number of IFOV retrievals comprising the accumulated SD total is used to convert the accumulated total from all daily descending granules into an average SD. The SD average is then converted to a SWE average with the snow density climatology file.

3.5.3 Snow Depth Retrieval

If snow presence is detected but it is likely to be shallow, the SD for the IFOV sample is estimated as 5.0 cm. For medium-to-deep snow, separate retrievals for forested and un-forested fractions are combined. The SD for the IFOV sample is calculated as:

$$SD = (ff * (SD_f)) + ((1 - ff) * (SD_o)),$$

where SDf = snow depth from the forested component of the IFOV, Sdo = snow depth from the non-forested component of the IFOV, and ff = forest fraction (1.0 = 100% forest fraction and 0.0 = 0% forest fraction).

The IFOV sample SD value is projected and added to the appropriate 25 km EASE-Grid cell.

3.5.4 SWE Estimation

After processing all granule sample SD and accumulating the SD in the 25 km EASE-Grid array, the average SD is computed for each 25 km EASE-Grid cell, also known as a drop in the bucket average. SWE is estimated for each cell using the snow depth and the ancillary snow density data:

$$SWE = SD\ (cm) * density\ (g\ cm^{-3}) * 10.0\ (mm)$$

Refer to the Format section of this document for information on scaling of SWE data.

See “Section 3.7 | Version History” for changes to the SWE products by algorithm.

3.6 Processing Steps

Daily granules are created by performing retrievals on individual AMSR-E Level-2A brightness temperature samples. The retrievals are then averaged to the 25 km Northern and Southern Hemisphere EASE-Grid. The 5-day maximum SWE granules are created from daily data composites. Derived snow variables from the daily product over the same grid cell are screened for consistency based on statistical tests described in the SWE Estimation section above. Maximum SWE is recorded.

Monthly averaged SWE granules are created from daily data composites. Derived snow variables from the daily product over the same grid cell are screened for consistency based on statistical tests. Mean SWE is recorded.

3.7 Version History

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

3.8 Errors and Limitations

Snow crystal size, snow detection in mountainous terrain, wet snow discrimination, and snow mapping in densely forested areas are factors that introduce errors into snow mapping and increase the variance of estimated SWE. Mapping snow in topographically-rough areas as if they were flat also causes errors in SWE estimation (Chang and Rango 2000).

3.9 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 Level-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).

3.9.1 Automatic QA

Chang visually examined random samples of SWE products to ensure they were consistent with an understanding of climate and that no gross errors were present. Future validation will involve comparing retrieved SWE values with estimates from airborne gamma observations over the U.S. (Carroll 1997) and with snow gauge data (Carroll et al. 1995), as well as comparing snow extent with MODIS snow maps (Chang and Rango 2000).

3.9.2 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 the following criteria for 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

3.9.3 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.

SWE is estimated for SD retrievals greater than 1 mm. Based on the 2002-2003 winter AMSR-E data and 38 coincident ground observations in the World Meteorological Organization (WMO) Global Telecommunications System (GTS) network, the standard error is 24.2 cm. Further validation is planned using multiple local, regional, and global data sets.

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

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For more information regarding related publications, see the Research Using AMSR-E Data Web page.

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6 DOCUMENT INFORMATION

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