AMSR-E/AMSR2 Unified L2B Global Swath Ocean Products, Version 1

USER GUIDE

How to Cite These Data

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

Kummerow, C., R. Ferraro and D. Duncan. 2021. *AMSR-E/AMSR2 Unified L2B Global Swath Ocean Products, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/9YQRFKKEPUP4. [Date Accessed].

TABLE OF CONTENTS

1 DATA DESCRIPTION

1.1 Parameters

This Level 2B, swath data set reports global water vapor and cloud liquid water content over ocean, plus sea surface wind speeds. The data are derived from resampled AMSR-E[1] and AMSR2[2] brightness temperature (T_b) observations, generated by the Japan Aerospace Exploration Agency (JAXA) to facilitate an intercalibrated (i.e., “unified”) AMSR-E/AMSR2 data record. Ancillary files, including product history, quality assessment (QA), and file-specific metadata are also provided.

1.2 File Information

1.2.1 Format

Data are provided in Hierarchical Data Format - Earth Observing System, Version 5 (HDF-EOS5) format. HDF-EOS is a file format and software library that augments standard HDF with conventions, data types, and metadata elements specific to NASA EOS mission data.

1.2.2 File Contents

ⓘ AMSR-E/AMSR2 Unified file names include a two-digit code that indicates whether they were derived from observations acquired by the AMSR-E (UE) or AMSR2 (U2) instrument.

Data within the HDF-EOS5 files are organized into two main groups:

HDFEOS
HDFEOS INFORMATION

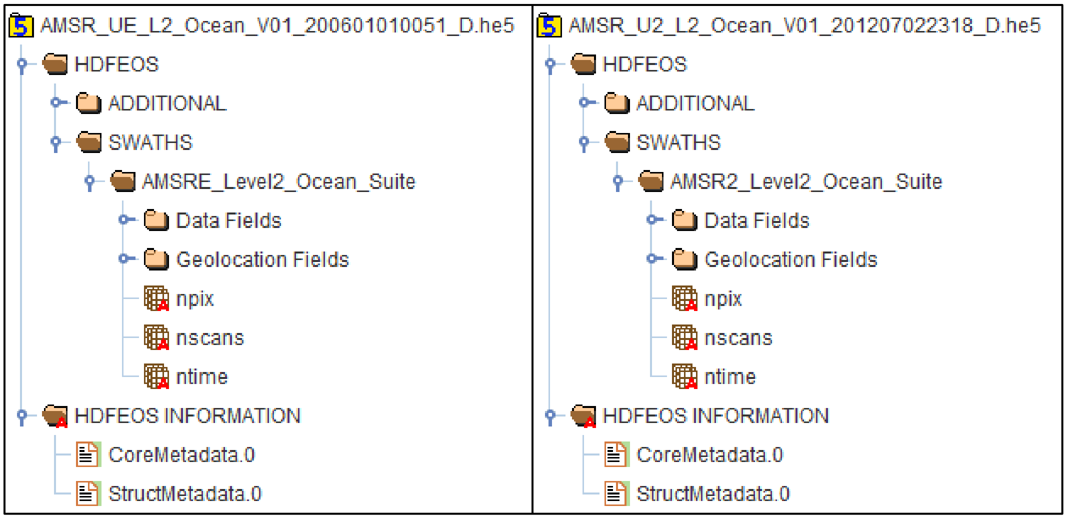
Science data are stored in the HDFEOS group, in the “Data_Fields” subgroup. Corresponding arrays of latitudes, longitudes, and observation times can be found at the same level in the “Geolocation_Fields” subgroup. “Data_Fields” and “Geolocation_Fields” are located within HDFEOS as follows (and as shown in Figure 1):

---

[1] Advanced Microwave Scanning Radiometer for EOS
[2] Advanced Microwave Scanning Radiometer 2

HDFEOS
└ SWATHS
  └ AMSRE_Level2_Ocean_Suite (or AMSR2_Level2_Ocean_Suite)
    └ Data_Fields
    └ Geolocation_Fields

The HDFEOS INFORMATION group contains the HDF-EOS global attributes “CoreMetadata.0” and “StructMetadata.0”.



- AMSR_UE_L2_Ocean_V01_200601010051_D.he5
  - HDFEOS
    - ADDITIONAL
    - SWATHS
      - AMSRE_Level2_Ocean_Suite
        - Data Fields
        - Geolocation Fields
        - npix
        - nscans
        - ntime
  - HDFEOS INFORMATION
    - CoreMetadata.0
    - StructMetadata.0

- AMSR_U2_L2_Ocean_V01_201207022318_D.he5
  - HDFEOS
    - ADDITIONAL
    - SWATHS
      - AMSR2_Level2_Ocean_Suite
        - Data Fields
        - Geolocation Fields
        - npix
        - nscans
        - ntime
  - HDFEOS INFORMATION
    - CoreMetadata.0
    - StructMetadata.0

Figure 1. Data Structures for AMSR-E (left) and AMSR2 (right) HDF-EOS5 Files as seen in HDFView.

The “npix,” “nscans,” and “ntime” variables in …/SWATHS/[AMSRE or AMSR2]_Level2_Ocean_Suite/ are NetCDF dimension scales. For more information, see NetCDF-4 Dimensions and HDF5 Dimension Scales.

Table 1 contains names and descriptions for the data fields stored in the Data Fields subgroup.

Table 1. Science Data Fields and Descriptions

Parameter (Data Type)	**Description**	**Fill Value**
ChiSquared (float)	Chi-squared (X^2) error metric of retrieval convergence: X^2 > number of channels: suspect X^2 > 18: of limited use (rainfall possible above these values) X^2 = -998.0: land/bad pixel X^2 = -997.0: quality issue	-9999.0

Parameter (Data Type)	Description	Fill Value
ErrorLWP* (float)	Posterior error (g/m2), liquid water path (LWP)	-9999.0
ErrorTPW* (float)	Posterior error (mm), total precipitable water (TPW)	-9999.0
ErrorWind* (float)	Posterior error (m/s), 10 m wind speed	-9999.0
LandPercentage** (byte)	Fraction of 6 GHz field-of-view that contains land (from L1R product)	-99
LiquidWaterPath (float)	Integrated liquid water (g/m2) in atmospheric column, cloud water only (see Section 2.3.2). Additional values: -998.0: land/bad pixel -997.0: quality issue	-9999.0
QualityFlag (byte)	Retrieval quality flag (see Section 2.3): 0: Highest quality 1: Convergence reached 2: No convergence (precipitation/land contamination possible) 3: TPW quality check failed (set to missing) 4: Sun glint angle < 20° (set to missing) 5: Not run (likely land/ice contamination)	-99
ReynoldsSST** (float)	Sea surface temperature (K) (from Reynolds Optimum Interpolation Sea Surface Temperature product)	-9999.0
SunGlintAngle (short)	Relative angle of reflection (°) between sun and instrument line of sight (-88 = visible solar disk below horizon)	-88
TimeHR (short)	High resolution scan times (year, month, day, hour, minute, second)	n/a
TotalPrecipitableWater (float)	Integrated water vapor (mm) in atmospheric column. Additional values: -998.0: land/bad pixel -997.0: quality issue	-9999.0
WindSpeed (float)	Ocean wind speed (m/s), 10-m altitude. Additional values: -998.0: land/bad pixel -997.0: quality issue	-9999.0

Table 2 describes the data fields stored in the Geolocation Fields subgroup.

---

[*] Computed as standard deviation of errors

[**] Ancillary parameter used as input to the AMSR Unified Rainfall algorithm

Table 2. Geolocation and Time Data Field Descriptions

Parameter (Data Type)	**Description**	**Fill Value**
Latitude (float)	Latitude of the pixel center (°N)	-9999.0
Longitude (float)	Longitude of the pixel center (°E)	-9999.0
Time (double)	Scan time along track, seconds since 01-01-1993 00:00:00 (TAI93)	-9999.0

1.2.3 File Naming Convention

Approximately 30, HDF-EOS5 data files (plus corresponding ancillary files) are generated each day—one for each ascending and descending half-orbit. Files are named according to the following convention:

Example

AMSR_UE_L2_Ocean_V01_200601010002_A.he5
AMSR_U2_L2_Ocean_V01_201207022318_D.he5

Naming Convention

AMSR_U[S]_L2_Ocean_[X][##]_[yyyymmdd][hhmm]_[O].[ext]

The following tables describe the variables in the naming convention above:

Table 3. File Name Variable Descriptions

Variable	**Description**
AMSR_U	AMSR-E/AMSR2 Unified
S	Sensor code: E = AMSR-E; 2 = AMSR2
L2_Ocean	Level-2 ocean product
X	Product Maturity Code (See Table 4)
##	File version number
yyyymmdd	Year (yyyy), month (mm), and day (dd) of data acquisition. E.g., 20060101 = 01 January, 2006.
hhmm	Hour and minute (UTC) of first scan in file

Variable	Description
O	Orbit code: A (ascending) or D (descending)
ext	File extension. One of: he5 = HDF-EOS5 ph = product history qa = quality assessment xml = metadata file

Table 4. Valid Values for the Product Maturity Code

Variable	Description
P	Preliminary: non-standard, near-real-time data. Preliminary data are only available until the corresponding standard product files are delivered to and made available by NSIDC.
B	Beta: created by a developing, product generation algorithm, with updates anticipated.
T	Transitional: period between beta and validated during which the algorithm matures and stabilizes. Transitional products are past the beta stage, but not quite ready for final validation.
V	Validated: data and algorithm have been verified by the algorithm and validation teams. Validated products may also have an associated validation stage.

1.2.4 Ancillary Data

A product history file (.ph) is available for each data file that contains information about the L1R input granule and product generation algorithm. A QA file (.qa) is also available that indicates the result of the science quality flag. Lastly, an XML file is provided which contains granule-specific metadata.

1.3 Spatial Information

1.3.1 Coverage

N: 89.24°	S: -89.24°	E: 180.0°	W: -180.0°

Figure 2 provides an example of the typical spatial coverage for this product during a single day.

1.3.2 Resolution

The pixel spacing is 10 km along track and 5 km along scan. However, the effective resolution depends on the field of view (FOV), which varies with frequency. Studies based on derived rainfall suggest the effective resolution is similar to the 22 GHz channel, or 26 km along track and 15 km along scan.

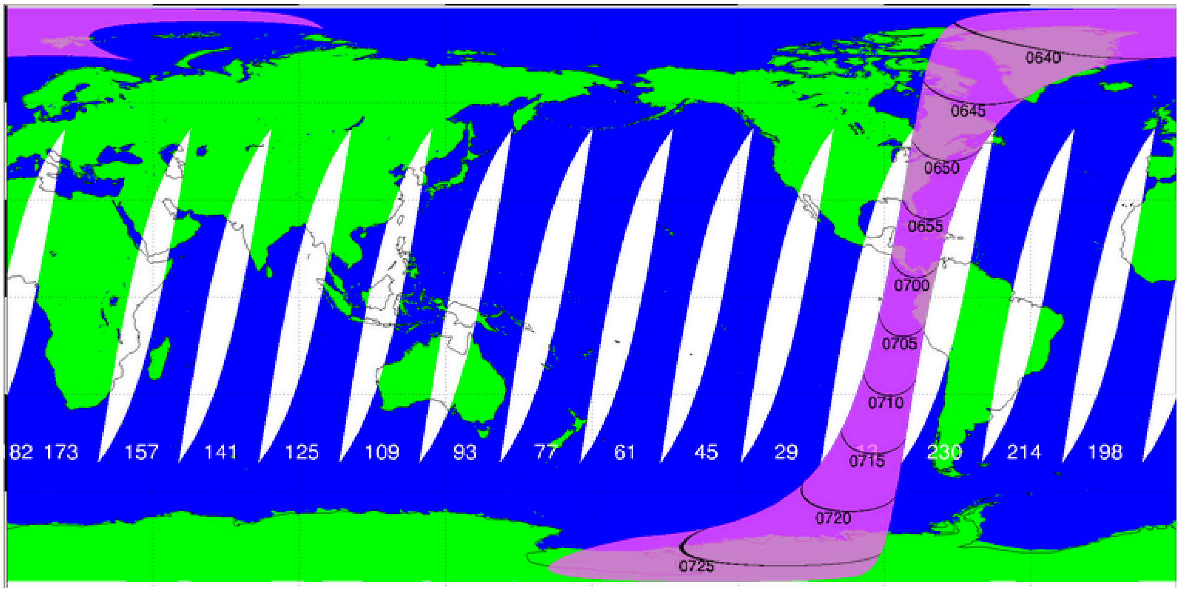


Figure 2. AMSR2 half-orbit, descending pass (purple) on 21 April 2020. Numbers (white) indicate the day's descending orbits.

1.3.3 Geolocation

The following table provides information for geolocating this data set:

Table 5. Geolocation Details

Geographic coordinate system	World Geodetic System 1984 (WGS 84)
Projected coordinate system	n/a
Longitude of true origin	Prime Meridian, Greenwich
Latitude of true origin	n/a
Scale factor at longitude of true origin	n/a
Datum	WGS 84
Ellipsoid/spheroid	WGS 84
Units	degree
False easting	n/a
False northing	n/a
EPSG code	4326

PROJ4 string	+proj=longlat +datum=WGS84 +no_defs +type=crs
Reference	https://epsg.io/4326

1.4 Temporal Information

1.4.1 Coverage

1 June 2002 to 4 October 2011 (AMSR-E)

2 July 2012 to the present (AMSR2)

No data are available from 04 October 2011 – 02 July 2012, between the end of the AMSR-E mission and the beginning of AMSR2.

1.4.2 Resolution

Each half-orbit swath spans approximately 50 minutes.

2 DATA ACQUISITION AND PROCESSING

2.1 Acquisition

To produce the L1R input data, AMSR-E and AMSR2 observations are resampled using the Backus-Gilbert method to remap T_bs from the two sensors—which utilize different main reflector and antenna configurations—into observations with consistent footprint sizes at each frequency. The L1R resampling theory and implementation are detailed in "Descriptions of GCOM-W1 AMSR2 Level 1R and Level 2 Algorithms".

In addition to the L1R data, the algorithm also utilizes the ancillary input data listed in Table 6.

Table 6. Ancillary data included in the AMSR Unified Ocean Algorithm

Product	**Parameter**	**Description**
GEOS-5 FP-IT*	Sea ice fraction	Fraction of grid cell covered by sea ice
NOAA 1/4° Daily Optimum Interpolation Sea Surface Temperature (OISST)**	Sea surface temperature	0.25° x 0.25° daily sea surface temperature. Included with output data as parameter "ReynoldsSST".

---

* NASA Global Modeling and Assimilation Office

** NOAA National Centers for Environmental Information

2.2 Processing

ⓘ The following sections summarize the matrix-based inverse method used to retrieve cloud liquid water content, atmospheric water vapor, and 10 m wind speed from AMSR-E and AMSR2 T_b observations. For a complete description, see “Section 3.1.1 | 1DVAR” in “AMSR-E/AMSR2 Unified Algorithm – Ocean Suite: Algorithm Theoretical Basis Document.”

The ocean suite algorithm iteratively solves for geophysical parameters by forward modeling the atmosphere and finding a solution that closely matches observed T_bs. It uses a 1D variational scheme, or 1DVAR (also known as optimal estimation), developed at Colorado State University (CSU 1DVAR).

1DVAR is a matrix-based inverse method based on Bayes’ Theorem, that blends observations and prior environmental knowledge, plus knowledge about the errors in both, to invert the measurement vector $\boldsymbol{Y}$ and determine the state vector $\boldsymbol{X}$. In this case, $\boldsymbol{Y}$ is a vector of T_bs and $\boldsymbol{X}$ is a vector that includes cloud liquid water content, 10 m wind speed, and atmospheric water vapor. CSU 1DVAR is novel in that the observation error covariances are not assumed to be zero, and empirical orthogonal functions (EOFs) are utilized to retrieve the vertical structure of the water vapor profile.

The atmospheric forward model comprises 16 vertical layers in pressure from 100 hPa to the surface, with surface pressure varying in accordance with sea level pressure from the reanalysis data while the other layers remain static. Simulated radiances are computed at AMSR frequencies using the Community Radiative Transfer Model (Liu and Weng, 2013). Prior information needed by the algorithm comes from NASA’s GEOS-5 FP-IT model.

Water vapor EOFs are defined as variations around mean profiles at different sea surface temperatures, calculated off-line from ERA-Interim[***] data. The algorithm solves for the coefficient of each EOF, which may be positive or negative, yielding a profile that best matches the T_b vector. The EOF-based approach was chosen as a compromise between allowing the channels’ weighting functions to guide the retrieved distribution of water vapor and requiring prior information to make the problem viable. It also helps mitigate regional biases in retrieved water vapor and reduces the dimensionality of the problem sufficiently to render it solvable.

The full inversion is solved iteratively via Newton’s method, assuming Gaussian-distributed errors and a moderately linear response of the measurements to changes in the state vector. Convergence is defined by a minimized cost function and sufficiently small changes in simulated T_bs between iterations (see equation 5.33 in Rodgers, 2000). Convergence is typically reached in

---

[***] ERA-Interim is a global, atmospheric reanalysis product produced by the European Centre for Medium-Range Weather Forecasts (ECMWF).

two iterations for clear skies and three-to-five iterations for cloudy scenes. A chi-squared metric (included with the product), normalized by the number of satellite channels, is computed to examine the quality of the convergence.

Finally, posterior errors (reported as the standard deviation of errors) are computed for total precipitable water (TPW), cloud integrated water, and 10 m wind speed and written to the output file.

2.3 Quality, Errors, and Limitations

2.3.1 Quality Flags

The "QualityFlag" variable (see "Section 1.2.2 | File Contents") included with the data file provides a general estimate of quality, from 0 to 5, for each pixel. The value for a pixel is initially set to 5, and then a series of tests are completed sequentially (from 0 to 4) which overwrite the value with a different code when applicable. Note that because each check overwrites any existing value for the pixel, a pixel which has triggered more than test will only indicate the result of last test it triggered.

Each coded value is described in the following table. Figure 3 below illustrates how the QualityFlag variable can be plotted to quickly assess data retrieval quality.

Table 7. Values for Quality Flag Parameter

Value	Definition
0	Highest quality retrieval
1	Convergence reached, but unsatisfactory chi-squared. Use with caution.
2	No convergence reached. Potential precipitation or land contamination.
3	TPW quality check failed. Value set to missing.
4	Sun glint angle < 20°. Value set to missing.
5	Not run due to land or sea ice

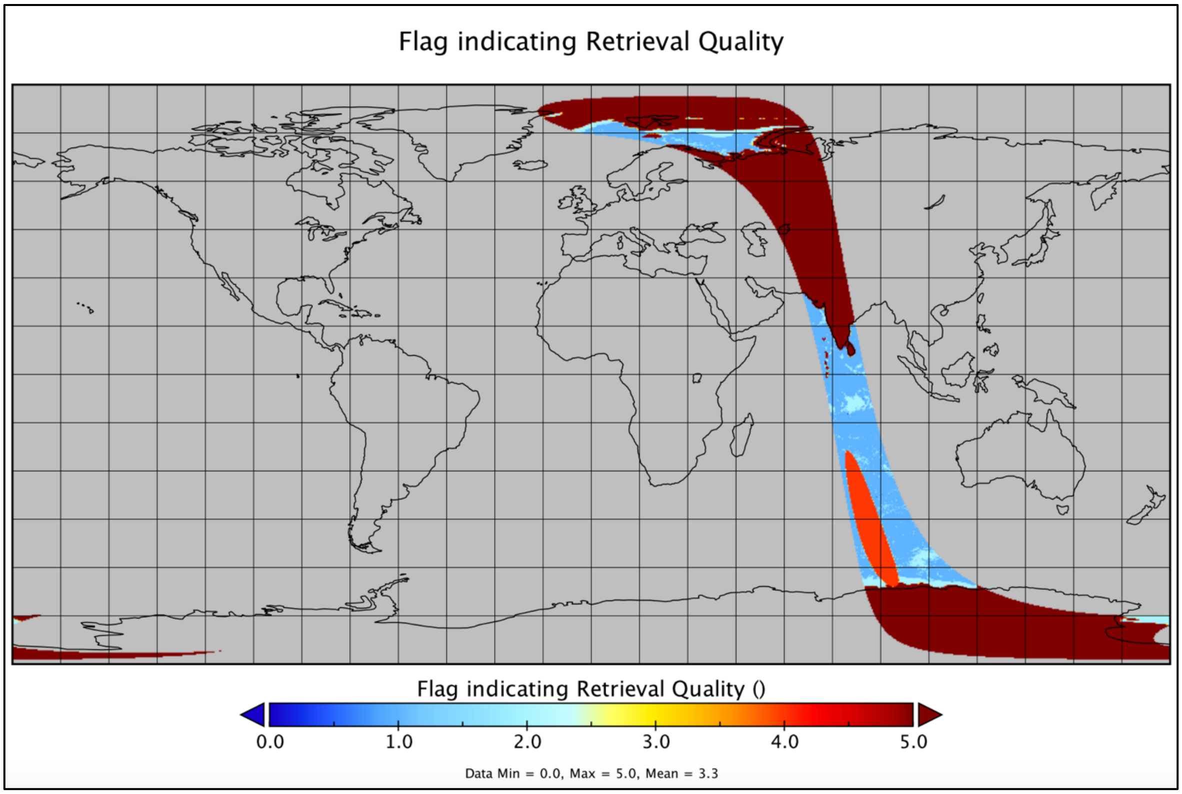


Figure 3. QualityFlag variable, 1 April 2020 as viewed in Panoply software.

2.3.2 Quality Fill Values

The parameters LiquidWaterPath, TotalPrecipitableWater, and WindSpeed have three possible flag values: -997[*], -998[*], and -9999.0. These values correspond to the following conditions:

-997: Quality issue due to:

- Problems with sea ice surface
- Atmospheric temperature profile has values less than 190 K

-998: Land or bad pixel due to:

- Sun glint angle between 0° and 20°
- Sea surface temperature < 271 K
- Earth incidence angle < 0°
- Missing T_b

---

[*] Assigned before the inversion is run to ensure the pixels are not processed

-9999.0: High quality T_b, but one of the following checks was triggered:

- Chi-squared value too high
- Number of iterations to convergence too high
- TPW value too high

2.3.3 Relationship between Quality Flag and Fill Values

As mentioned above, pixels can have more than one of the issues described by QualityFlag. Fill values are especially useful under these circumstances. Fill values may be associated with QualityFlag values as follows:

QualityFlag = 0

- Good retrieval
- No -997, -998, or -9999.0 values present.

QualityFlag = 1

- The inversion converged, but the chi-squared value was not good
- No -997, -998, or -9999.0 values present

QualityFlag = 2:

- No convergence due to high chi-squared value, number of iterations, or high TPW
- -9999.0 present

QualityFlag = 3

- TPW quality check failed
- -9999.0 present

QualityFlag = 4:

- Algorithm is *only* run for pixels with -997 or -998 when the -998 value was triggered by a sun glint angle between 0° and 20°.
- In this case, the QualityFlag value will be set to 4.

2.3.4 Product Generation QA

The CoreMetadata.0 global attribute included with each HDF-EOS5 data granule contains the results of QA checks run by the product generation processing code when the AMSR Science Investigator-Led Processing System (SIPS) creates the granule. This information is also available in a separate XML file HDF-EOS5 file (see "Section 1.2.4 | Ancillary Data").

A data granule must pass two levels of QA before the SIPS will deliver it to NSIDC: automated and operational. Granules that fail either level are reprocessed. Although science QA is also performed automatically, it is only reviewed closely if questions arise after processing is complete.

The following sections briefly describe the automatic, operational, and science QA as they apply to this data set.

2.3.5 Automated QA

L1R data are screened and out-of-bounds T_bs are removed before being input to the product generation algorithm.

2.3.6 Operational QA

Operational QA confirms that the file:

- Is in the expected format
- Is correctly named and sized
- Contains all expected elements
- Has the correct metadata
- Is not a duplicate
- Was processed using the correct input files

2.3.7 Science QA

Science QA checks that science parameters do not violate prescribed norms, such as minimum and maximum bounds and allowed percentages of missing data. In addition, the Science Computing Facility (SCF), co-located with the SIPS, performs post-processing science QA to identify:

- Anomalous deviations from historical data
- Geolocation errors
- Systemic trends in calibration data
- Large scatter among data points that should be consistent

2.4 Instrumentation

2.4.1 Description

AMSR-E was a modified version of the AMSR instrument on JAXA's Advanced Earth Observing Satellite-II (ADEOS-II). It was developed at JAXA in cooperation with U.S. and Japanese scientists for the NASA Aqua satellite mission. For more information about AMSR-E, see AMSR-E Instrument Description.

AMSR2 was launched on May 18, 2012 on board JAXA's GCOM-W1 satellite. Additional information about the AMSR2 instrument is available on the GCOM-W1 | AMSR2 Channel Specification and Products page.

3 SOFTWARE AND TOOLS

See the HDF-EOS Tools and Information web page.

4 CONTACTS AND ACKNOWLEDGMENTS

Christian Kummerow
Department of Atmospheric Science
Colorado State University
Fort Collins, CO

Ralph Ferraro
Earth System Science Interdisciplinary Center
University of Maryland
College Park, MD

David Duncan
European Centre for Medium-Range Weather Forecasts
Reading, United Kingdom

Paula Brown
Department of Atmospheric Science
Colorado State University
Fort Collins, CO

Amy Lin
Global Hydrometeorology Resource Center DAAC
University of Alabama in Huntsville
Huntsville, AL

5 REFERENCES

Aires, F., Prigent, C., Bernardo, F., Jiménez, C., Saunders, R., & Brunel, P. (2011). A Tool to Estimate Land-Surface Emissivities at Microwave frequencies (TELSEM) for use in numerical weather prediction. *Quarterly Journal of the Royal Meteorological Society* 137(656), 690–699. https://doi.org/10.1002/qj.803

Berg, W., L'Ecuyer, T., & Kummerow, C. (2006). Rainfall Climate Regimes: The Relationship of Regional TRMM Rainfall Biases to the Environment. *Journal of Applied Meteorology and Climatology* 45(3), 434–454. https://doi.org/10.1175/jam2331.1

Conway, D. 2002. *Advanced Microwave Scanning Radiometer - EOS Quality Assurance Plan*. Huntsville, AL Global Hydrology and Climate Center.

Duncan, D. and C. Kummerow. (2016). A 1DVAR retrieval applied to GMI: Algorithm description, validation, and sensitivities: GMI 1DVAR Retrieval. Journal of Geophysical Research: Atmospheres, 121. https://doi.org/10.1002/2016JD024808.

Hou, A. Y., Kakar, R. K., Neeck, S., Azarbarzin, A. A., Kummerow, C. D., Kojima, M., Oki, R., Nakamura, K., & Iguchi, T. (2014). The Global Precipitation Measurement Mission. *Bulletin of the American Meteorological Society* 95(5), 701–722. https://doi.org/10.1175/bams-d-13-00164.1

Kummerow, C. D., Randel, D. L., Kulie, M., Wang, N.-Y., Ferraro, R., Joseph Munchak, S., & Petkovic, V. (2015). The Evolution of the Goddard Profiling Algorithm to a Fully Parametric Scheme. *Journal of Atmospheric and Oceanic Technology* 32(12), 2265–2280. https://doi.org/10.1175/jtech-d-15-0039.1

Kummerow, C. D., Ringerud, S., Crook, J., Randel, D., & Berg, W. (2011). An Observationally Generated A Priori Database for Microwave Rainfall Retrievals. *Journal of Atmospheric and Oceanic Technology* 28(2), 113–130. https://doi.org/10.1175/2010jtecha1468.1

Liu, Q. and F. Weng. (2013). Using Advanced Matrix Operator (AMOM) in Community Radiative Transfer Model," *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 6(3) 1211-1218. https://doi.org/10.1109/JSTARS.2013.2247026

Lorenc, A. C. (1986). Analysis methods for numerical weather prediction. *Quarterly Journal of the Royal Meteorological Society* 112(474), 1177–1194. https://doi.org/10.1002/qj.49711247414

Maeda, T., Taniguchi, Y., and K. Imaoka. (2016). GCOM-W1 AMSR2 Level 1R Product: Dataset of Brightness Temperature Modified Using the Antenna Pattern Matching Technique. *IEEE Transactions on Geoscience and Remote Sensing* 54(2), 770-782. https://doi.org/10.1109/TGRS.2015.2465170.

Reynolds, R. W., Smith, T. M., Liu, C., Chelton, D. B., Casey, K. S., & Schlax, M. G. (2007). Daily High-Resolution-Blended Analyses for Sea Surface Temperature. *Journal of Climate* 20(22), 5473–5496. https://doi.org/10.1175/2007jcli1824.1

Rodgers, C. D. (2000). *Inverse Methods for Atmospheric Sounding: Theory and Practice*. World Scientific Publishing Co., Singapore.

6 DOCUMENT INFORMATION

6.1 Publication Date

December 2021

6.2 Date Last Updated

June 2023