CloudSat Project

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CloudSat AMSR2-AUX Auxiliary Data Product Process Description and Interface Control Document

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1 INTRODUCTION

The AMSR2-AUX data set is an intermediate product that contains a subset of ancillary AMSR2 surface precipitation and ocean products data collocated with each CloudSat cloud profiling radar (CPR) footprint. Input data are obtained from the AN-AMSR2 dataset, provided by the National Snow and Ice Data Center (NSIDC), and the CloudSat 1B-CPR product. This document describes the subset process, input product specifications, and format of the ASMR2-AUX product.

2 DESCRIPTION OF THE SUBSET PROCESS

The AN-AMSR2 data contain selected AMSR-E/AMSR2 Unified L2B Global Swath Ocean Products (AU_Ocean; Kummerow et al., 2021) and Global Swath Surface Precipitation (AU_Rain; Kummerow et al., 2020) data fields and geolocation at a nominal resolution of 10 km along track and 5 km along scan (see Section 3.2 for a more detailed description). To produce the AMSR2-AUX product, geolocation data from the 1B-CPR product are used as the reference dataset. Operating one CloudSat ray at a time and using a great-circle nearest-neighbor scheme (Pedregosa et al., 2011), the closest AN-AMSR2 pixel is located. Once found, values are extracted from the AN-AMSR2 data fields of interest that correspond to the closest pixel and put into the appropriate resulting AMSR2-AUX field. If the CloudSat geolocation for a particular ray is missing, if the closest AN-AMSR2 pixel is more than 10 kilometers from the CloudSat ray, or if the AN-AMSR2 pixels located within 10 kilometers of the CloudSat ray were not observed within 10 minutes of the CloudSat data, the resulting AMSR2 geolocation data and the associated data fields are filled with a missing value flag.

3 ALGORITHM INPUTS

3.1 1B-CPR Specifications

The 1B-CPR product is provided in HDF-EOS2 format by the CloudSat Data Processing Center at Colorado State University's Cooperative Institute for Research in the Atmosphere (CIRA). Fields available in the 1B-CPR P_R05 dataset used by this algorithm include:

(1) Seconds since the start of the granule

Name in file: Profile_time
Source: 1B-CPR P_R05
Field type (in file): REAL(4)
Field type (in algorithm): REAL(4)
Dimensions: nray
Units: seconds
Range: 0 to 6000
Missing value: N/A
Missing value operator: N/A
Factor: 1
Offset: 0

Seconds since the start of the granule for each profile. The first profile is 0.

(2) UTC seconds since 00:00 Z of the first profile

Name in file: UTC_start
Source: 1B-CPR P_R05
Field type (in file): REAL(4)
Field type (in algorithm): REAL(4)
Dimensions: <scalar>
Units: seconds
Range: 0 to 86400
Missing value: N/A
Missing value operator: N/A
Factor: 1
Offset: 0

The UTC seconds since 00:00 Z of the first profile in the data file.

(3) TAI time for the first profile

Name in file: TAI_start
Source: 1B-CPR P_R05
Field type (in file): REAL(8)
Field type (in algorithm): REAL(8)
Dimensions: <scalar>
Units: seconds
Range: 0 to 6×10^{8}
Missing value: N/A
Missing value operator: N/A
Factor: 1
Offset: 0

The International Atomic Time (TAI time) as the number of seconds since January 1, 1993 00:00:00Z.

(4) Spacecraft Latitude

Name in file: Latitude
Source: 1B-CPR P_R05
Field type (in file): REAL(4)
Field type (in algorithm): REAL(4)
Dimensions: nray
Units: degrees
Range: -90 to 90
Missing value: N/A
Missing value operator: N/A
Factor: 1
Offset: 0

The geodetic latitude (degrees) of the boresight/geoid intersection.

(5) Spacecraft Longitude

Name in file: Longitude
Source: 1B-CPR P_R05
Field type (in file): REAL(4)
Field type (in algorithm): REAL(4)
Dimensions: nray
Units: degrees
Range: -180 to 180
Missing value: N/A
Missing value operator: N/A
Factor: 1
Offset: 0

The geodetic longitude (degrees) of the boresight/geoid intersection.

3.2 AN-AMSR2 Specifications: AU_Rain

The AN-AMSR2 Version 1 dataset provided by the NSIDC includes two products used as input to AMSR2_AUX, July 2012-present: AMSR-E/AMSR2 Unified L2B Global Swath Surface Precipitation, Version 1 (AU_Rain; Kummerow et al., 2020) and AMSR-E/AMSR2 Unified L2B Global Swath Ocean Products, Version 1 (AU_Ocean; Kummerow et al., 20201). Files are provided in HDF-EOS5 format.

The AU_Rain global dataset reports instantaneous surface precipitation rate and type over land and ocean, and precipitation profiles over ocean. The AMSR Unified Rainfall algorithm uses intercalibrated L1R brightness temperatures provided by Japan Aerospace Exploration Agency (JAXA) for AMSR-E (flown on the EOS-Aqua) and AMSR2 (flown on GCOM-W) to create a consistent precipitation data record from the two satellites (Kummerow et al., 2020). Fields available in the AU_Rain dataset used by this algorithm include:

(1) Total cloud liquid water in the atmospheric column

Name in file: CloudWaterPath
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nscans, npixs
Units: kg/m^2
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(2) The instantaneous convective precipitation rate

Name in file: ConvectivePrecip
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nscans, npixs
Units: mm/hr
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(3) Total cloud ice in the atmospheric column

Name in file: IceWaterPath
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nscans, npixs
Units: kg/m^2
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(4) Total rain water in the atmospheric column

Name in file: RainWaterPath
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nscans, npixs
Units: kg/m^2
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(5) The instantaneous total precipitation rate

Name in file: SurfacePrecip
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nscans, npixs
Units: mm/hr
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(6) Integrated water vapor in the atmospheric column

Name in file: TotalColWaterVapor
Source: AN-AMSR2 AU_Rain
Field type (in file): INT(1)
Dimensions: nscans, npixs
Units: mm
Range: N/A
Missing value: -99
Missing value operator: ==
Factor: 1
Offset: 0

Integrated water vapor in the atmospheric column (TCWV); synonymous with Total Precipitable Water (TPW) (Kummerow et al., 2020).

(7) Flag indicating retrieval quality

Name in file: QualityFlag
Source: AN-AMSR2 AU_Rain
Field type (in file): INT(1)
Dimensions: nscans, npixs
Units: N/A
Range: 0 to 3
Missing value: -99
Missing value operator: ==
Factor: 1
Offset: 0

This quality flag provides an indication of the retrieval quality. Flag meanings: 0: Good, Pixel has the highest confidence of the best retrieval; 1: Use with caution, Pixels can be set to 1 for the following reasons: Sunglint is present, RFI geolocate warm load, or for other L1R positive value quality warning flags; 2: Use pixel with extreme care over snow covered surface, This is a special value for snow-covered surfaces only. The pixel is set to 2 if the probability of precipitation is of poor quality or indeterminate. Use these pixels for climatological averaging of precipitation but not for individual storm-scale daily cases; 3: Use with extreme caution, Pixels are set to 3 if they have channels missing critical to the retrieval but the choice has been made to continue the retrieval for the pixel (Kummerow et al., 2020).

(8) Latitude of the pixel center

Name in file: Latitude
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nscans, npixs
Units: degrees north
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(9) Longitude of the pixel center

Name in file: Longitude
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nscans, npixs
Units: degrees east

Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(10) Scan time along track

Name in file: tai93time
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(8)
Dimensions: nscans
Units: seconds

Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

Scan time along track measured in seconds since 1993-01-01 00:00:00 (Kummerow et al., 2020).

3.3 AN-AMSR2 Specifications: AU_Ocean

The AU_Ocean global dataset reports the global water vapor over ocean, cloud liquid water content over ocean, and sea surface wind speed using resampled NRT Level-1R data provided by JAXA (Kummerow et al., 2021). Fields available in the AU_Ocean dataset used by this algorithm include:

(1) Integrated liquid water in the atmospheric column for cloud water only

Name in file: LiquidWaterPath
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(4)
Dimensions: npix, nscans
Units: g/m^2

Range: 0 to 3000
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

Fill values: -998 indicates land or bad pixel; -997 indicates a quality issue (Kummerow et al., 2021).

(2) Sea surface temperature taken from the Reynolds Optimum Interpolation Sea Surface Temperature product

Name in file: ReynoldsSST
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(4)
Dimensions: npix, nscans
Units: K

Range: 268.15 to 323.15
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(3) Integrated water vapor in the atmospheric column

Name in file: TotalPrecipitableWater
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(4)
Dimensions: npix, nscans
Units: mm
Range: 0 to 75
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

Fill values: -998 indicates land or bad pixel; -997 indicates a quality issue (Kummerow et al., 2021).

(4) Ocean wind speed at 10-meter altitude integrated from retrieved profile.

Name in file: WindSpeed
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(4)
Dimensions: npix, nscans
Units: m/s
Range: 0 to 50
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

Fill values: -998 indicates land or bad pixel; -997 indicates a quality issue (Kummerow et al., 2021).

(5) Flag indicating retrieval quality

Name in file: QualityFlag
Source: AN-AMSR2 AU_Ocean
Field type (in file): INT(1)
Dimensions: npix, nscans
Units: N/A
Range: 0 to 5
Missing value: -99
Missing value operator: ==
Factor: 1
Offset: 0

This quality flag provides an indication of the retrieval quality. Flag meanings: 0: Highest quality retrieval; 1: Convergence reached; 2: No convergence; precipitation or land contamination possible; 3: TPW quality check failed, set to missing; 4: Sun glint angle less than 20 degrees, set to missing; 5: Not run likely due to land/ice contamination (Kummerow et al., 2021)

(6) Latitude of the pixel center

Name in file: Latitude
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(4)
Dimensions: npix, nscans
Units: degrees north
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(7) Longitude of the pixel center

Name in file: Longitude
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(4)
Dimensions: npix, nscans
Units: degrees east
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(8) Scan time along track

Name in file: Time
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(8)
Dimensions: nscans
Units: seconds

Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

Scan time along track measured in seconds since 1993-01-01 00:00:00 (Kummerow et al., 2021).

4 DATA PRODUCT OUTPUT SPECIFICATIONS

Each HDF-EOS2 product file is built for the orbit specified by the input 1B-CPR data. Within each file, the Geolocation Fields contain the ASMR2 geolocation of the subset pixels along with time information for the CloudSat ray. The Data Fields contain the AMSR2 science data for the subset pixels as well as information tracing back to the input AN-ASMR2 files. The specifications for the AMSR2-AUX P_R05 product are as follows:

(1) Total cloud liquid water in the atmospheric column

Name in file: CloudWaterPath
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nray
Units: kg/m^2

Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(2) The instantaneous convective precipitation rate

Name in file: ConvectivePrecip
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nray
Units: mm/hr

Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(3) Total cloud ice in the atmospheric column

Name in file: IceWaterPath
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nray
Units: kg/m^2

Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(4) Integrated liquid water in the atmospheric column for cloud water only

Name in file: LiquidWaterPath
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(4)
Dimensions: nray
Units: g/m^2
Range: 0 to 3000
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

Fill values: -998 indicates land or bad pixel; -997 indicates a quality issue (Kummerow et al., 2021).

(5) AU_Ocean flag indicating retrieval quality

Name in file: Ocean_QualityFlag
Source: AN-AMSR2 AU_Ocean
Field type (in file): INT(1)
Dimensions: nray
Units: N/A
Range: 0 to 5
Missing value: -99
Missing value operator: ==
Factor: 1
Offset: 0

This quality flag provides an indication of the retrieval quality. Flag meanings: 0: Highest quality retrieval; 1: Convergence reached; 2: No convergence; precipitation or land contamination possible; 3: TPW quality check failed, set to missing; 4: Sun glint angle less than 20 degrees, set to missing; 5: Not run likely due to land/ice contamination (Kummerow et al., 2021)

(6) AU_Rain flag indicating retrieval quality

Name in file: Rain_QualityFlag
Source: AN-AMSR2 AU_Rain
Field type (in file): INT(1)
Dimensions: nray
Units: N/A
Range: 0 to 3
Missing value: -99
Missing value operator: ==
Factor: 1
Offset: 0

This quality flag provides an indication of the retrieval quality. Flag meanings: 0: Good, Pixel has the highest confidence of the best retrieval; 1: Use with caution, Pixels can be set to 1 for the following reasons: Sunglint is present, RFI geolocate warm load, or for other L1R positive value quality warning flags; 2: Use pixel with extreme care over snow covered surface, This is a special value for snow-covered surfaces only. The pixel is set to 2 if the probability of precipitation is of poor quality or indeterminate. Use these pixels for climatological averaging of precipitation but not for individual storm-scale daily cases; 3: Use with extreme caution, Pixels are set to 3 if they have channels missing critical to the retrieval but the choice has been made to continue the retrieval for the pixel (Kummerow et al., 2020).

(7) Total rain water in the atmospheric column

Name in file: RainWaterPath
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nray
Units: kg/m^2
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(8) Sea surface temperature taken from the Reynolds Optimum Interpolation Sea Surface Temperature product

Name in file: ReynoldsSST
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(4)
Dimensions: nray
Units: K
Range: 268.15 to 323.15
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(9) The instantaneous total precipitation rate

Name in file: SurfacePrecip
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nray
Units: mm/hr
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(10) Integrated water vapor in the atmospheric column

Name in file: TotalColWaterVapor
Source: AN-AMSR2 AU_Rain
Field type (in file): INT(1)
Dimensions: nray
Units: mm
Range: N/A
Missing value: -99
Missing value operator: ==
Factor: 1
Offset: 0

Integrated water vapor in the atmospheric column (TCWV); synonymous with Total Precipitable Water (TPW) (Kummerow et al., 2020).

(11) Integrated water vapor in the atmospheric column

Name in file: TotalPrecipitableWater
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(4)
Dimensions: nray
Units: mm
Range: 0 to 75
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

Fill values: -998 indicates land or bad pixel; -997 indicates a quality issue (Kummerow et al., 2021).

(12) Ocean wind speed at 10-meter altitude integrated from retrieved profile.

Name in file: WindSpeed
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(4)
Dimensions: nray
Units: m/s
Range: 0 to 50
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

Fill values: -998 indicates land or bad pixel; -997 indicates a quality issue (Kummerow et al., 2021).

(13) Spacecraft Latitude

Name in file: Latitude
Source: 1B-CPR P_R05
Field type (in file): REAL(4)
Dimensions: nray
Units: degrees north
Range: -90 to 90
Missing value: N/A
Missing value operator: N/A
Factor: 1
Offset: 0

The geodetic latitude (degrees) of the boresight/geoid intersection.

(14) Spacecraft Longitude

Name in file: Longitude
Source: 1B-CPR P_R05
Field type (in file): REAL(4)
Dimensions: nray
Units: degrees east
Range: -180 to 180
Missing value: N/A
Missing value operator: N/A
Factor: 1
Offset: 0

The geodetic longitude (degrees) of the boresight/geoid intersection.

(15) AU_Ocean latitude of the pixel center

Name in file: Ocean_Latitude
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(4)
Dimensions: nray
Units: degrees north
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(16) AU_Ocean longitude of the pixel center

Name in file: Ocean_Longitude
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(4)
Dimensions: nray
Units: degrees east
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(17) AU_Ocean scan time along track

Name in file: Ocean_Time
Source: AN-AMSR2 AU_Ocean
Field type (in file): REAL(8)
Dimensions: nray
Units: seconds
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

Scan time along track measured in seconds since 1993-01-01 00:00:00 (Kummerow et al., 2021).

(18) Seconds since the start of the granule

Name in file: Profile_time
Source: 1B-CPR P_R05
Field type (in file): REAL(4)
Dimensions: nray
Units: seconds
Range: 0 to 6000
Missing value: N/A
Missing value operator: N/A
Factor: 1
Offset: 0

Seconds since the start of the granule for each profile. The first profile is 0.

(19) AU_Rain latitude of the pixel center

Name in file: Rain_Latitude
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nray
Units: degrees north
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(20) AU_Rain longitude of the pixel center

Name in file: Rain_Longitude
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(4)
Dimensions: nray
Units: degrees east
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

(21) AU_Rain scan time along track

Name in file: Rain_tai93time
Source: AN-AMSR2 AU_Rain
Field type (in file): REAL(8)
Dimensions: nray
Units: seconds
Range: N/A
Missing value: -9999
Missing value operator: ==
Factor: 1
Offset: 0

Scan time along track measured in seconds since 1993-01-01 00:00:00 (Kummerow et al., 2020).

(22) TAI time for the first profile

Name in file: TAI_start
Source: 1B-CPR P_R05
Field type (in file): REAL(8)
Dimensions: <scalar>
Units: seconds
Range: 0 to 6×10^8
Missing value: N/A
Missing value operator: N/A
Factor: 1
Offset: 0

The International Atomic Time (TAI time) as the number of seconds since January 1, 1993 00:00:00Z.

(23) UTC seconds since 00:00 Z of the first profile

Name in file: UTC_start
Source: 1B-CPR P_R05
Field type (in file): REAL(4)
Dimensions: <scalar>
Units: seconds
Range: 0 to 86400
Missing value: N/A
Missing value operator: N/A
Factor: 1
Offset: 0

The UTC seconds since 00:00 Z of the first profile in the data file.

5 CAVEATS AND KNOWN ISSUES

None at this time.

6 ACRONYM LIST

AMSR2	Advanced Microwave Scanning Radiometer 2
AU_Ocean	AMSR-E/AMSR2 Unified L2B Global Swath Ocean Products, Version 1
AU_Rain	AMSR-E/AMSR2 Unified L2B Global Swath Surface Precipitation, Version 1
CIRA	Cooperative Institute for Research in the Atmosphere
CPR	Cloud Profiling Radar
EOS	Earth Observing System
GCOM	Global Change Observation Mission
HDF	Hierarchical Data Format
JAXA	Japan Aerospace Exploration Agency
NSIDC	National Snow and Ice Data Center
TCWV	Integrated water vapor in the atmospheric column
TPW	Total precipitable water

7 REFERENCES

Kummerow, C., R. Ferraro, and D. Duncan. 2021. AMSR-E/AMSR2 Unified L2B Global Swath Ocean Products, Version 1. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/9YQRFKKEPUP4. Accessed 6/13/2022.

Kummerow, C., R. Ferraro, and D. Randel. 2020. AMSR-E/AMSR2 Unified L2B Global Swath Surface Precipitation, Version 1. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/P5MCTDH7674A. Access 6/13/2022.

Pedregosa, F.P., Varoquaux, G., Gramfort, A., Michel, V., Thirion, B., Grisel, O., Blondel, M., Prettenhofer, P., Weiss, R., Dubourg, V., Vanderplas, J., Passos, A., Cournapeau, D., Brucher, M., Perrot, M., Duchesnay, E. 2011. Scikit-learn: Machine Learning in Python. JMLR 12(85):2825−2830.