# AMSR-E/Aqua L2B Global Swath Ocean Products derived from Wentz Algorithm, Version 2

## USER GUIDE

**How to Cite These Data**

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

Wentz, F. J. and T. Meissner. 2004. *AMSR-E/Aqua L2B Global Swath Ocean Products derived from Wentz Algorithm, 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_OCEAN.002. [Date Accessed].

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

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

National Snow and Ice Data Center

# TABLE OF CONTENTS

# 1 DATA DESCRIPTION

## 1.1 Parameters

- SST (°C)
- Near-surface wind speed (m/s)
- Columnar water vapor (mm)
- Columnar cloud liquid water (mm)
- RFI glint angle

## 1.2 File Information

### 1.2.1 Format

Data are in HDF-EOS format. The data fields are summarized in Table 2 and Table 3.

Tables 2 and 3 use the following notations to describe the data types:

Table 1. Data Type Notations

| | |
|---|---|
| **Float64:** | 64-bit (8-byte) floating-point |
| **Float32:** | 32-bit (4-byte) floating-point |
| **Int8:** | 8-bit (1-byte) signed integer |
| **Int16:** | 16-bit (2-byte) signed integer |
| **Int32:** | 32-bit (4-byte) signed integer |

Note: Beginning with algorithm Version B03, the samples in the Level-2B data increased from 196 to 243 due to utilization of the entire swath.

The following Level-2B fields exist for both ascending and descending passes:

Table 2. Level-2B Ocean Fields

| Field Name | Data Type | Description | Scale Factor |
|---|---|---|---|
| Position_in_orbit | Float64 | Position in orbit<br>Dimensions: One-dimensional (no scans) | n/a |
| Scan_quality_flag | Int32 | Overall quality flag<br>Dimensions: Approximately 2000 scans | n/a |

| Field Name | Data Type | Description | Scale Factor |
|---|---|---|---|
| Ocean_summary_quality flag | Int8 | See Quality Assessment section. Dimensions: Approximately 2000 scans | n/a |
| Ocean_products_quality_flag | Int8 | See Quality Assessment section. Dimensions: Approximately 2000 scans x 243 samples x 6 | n/a |
| Very_low_res_sst | Int16 | SST (°C) at 56 km resolution of 6.9 GHz footprint Dimensions: Approximately 2000 scans x 243 samples | Multiply data values by 0.01 to obtain units in°C. |
| Low_res_sst | Int16 | SST (°C) at 38 km resolution of 10.7 GHz footprint Dimensions: Approximately 2000 scans x 243 samples | Multiply data values by 0.01 to obtain units in °C. |
| Low_res_wind | Int16 | Wind speed (m/s) at 38 km resolution of 10.7 GHz footprint Dimensions: Approximately 2000 scans x 243 samples | Multiply data values by 0.01 to obtain units in m/s. |
| Med_res_wind | Int16 | Wind speed (m/s) at 21 km resolution of 18.9 GHz footprint Dimensions: Approximately 2000 scans x 243 samples | Multiply data values by 0.01 to obtain units in m/s. |
| Med_res_vapor | Int16 | Columnar water vapor (mm) at 21 km resolution of 18.9 GHz footprint Dimensions: Approximately 2000 scans x 243 samples | Multiply data values by 0.01 to obtain units in mm. |
| High_res_cloud | Int16 | Columnar cloud liquid water (mm) at 12 km resolution of 36.5 GHz footprint Dimensions: Approximately 2000 scans x 243 samples | Multiply data values by 0.0001 to obtain units in mm. |

Table 3. Level-2B Geolocation Fields

| Field Name | Data Type | Description |
|---|---|---|
| Time | Float64 | Scan start time in International Atomic Time in seconds with 01 January 1993 00:00:00 as the zero base (TAI93) Dimensions: Approximately 2000 scans |

| Field Name | Data Type | Description |
|---|---|---|
| Latitude | Float32 | Latitude (-90.0 to 90.0)<br>Dimensions: Approximately 2000 scans x 243 samples |
| Longitude | Float32 | Longitude (-180.0 to 180.0)<br>Dimensions: Approximately 2000 scans x 243 samples |

Table 4 provides descriptions for the Level-3 Ocean Fields. All grids are 720 rows x 1440 columns of signed 2-byte integers.

Table 4. Level-3 Ocean Fields

| Field Name | Description | Scale Factor |
|---|---|---|
| Very_low_res_sst | SST (°C) at 56 km resolution of 6.9 GHz footprint | Multiply data values by 0.01 to obtain units in °C. |
| Low_res_sst | SST (°C) at 38 km resolution of 10.7 GHz footprint | Multiply data values by 0.01 to obtain units in°C. |
| Low_res_wind | Wind speed (m/s) at 38 km resolution of 10.7 GHz footprint | Multiply data values by 0.01 to obtain units in m/s. |
| Med_res_wind | Wind speed (m/s) at 21 km resolution of 18.9 GHz footprint | Multiply data values by 0.01 to obtain units in m/s. |
| Med_res_vapor | Columnar water vapor (mm) at 21 km resolution of 18.9 GHz footprint | Multiply data values by 0.01 to obtain units in mm. |
| High_res_cloud | Columnar cloud liquid water (mm) at 12 km resolution of 36.5 GHz footprint | Multiply data values by 0.0001 to obtain units in mm. |
| RFI_angle | Glint angles are provided for determining RFI. A glint angle of 0° is a direct reflection; glint angles above 20° are unlikely to have significant RFI. | Multiply data values by 0.10 to obtain units in degrees. |

### 1.2.2 File Contents

Half-orbit Level-2B granules are approximately 12 MB each. Level-3 granules are 12.5 MB each.

### 1.2.3 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 Names

```
AMSR_E_L2_Ocean_V05_200709022352_A.hdf
AMSR_E_L3_DailyOcean_V03_20020619.hdf
AMSR_E_L3_WeeklyOcean_B02_20070701.hdf
AMSR_E_L3_MonthlyOcean_B02_200707.hdf
```

### Naming Convention

```
AMSR_E_L2_Ocean_X##_yyyymmddhhmm_f.hdf
AMSR_E_L3_DailyOcean_X##_yyyymmdd.hdf
AMSR_E_L3_WeeklyOcean_X##_yyyymmdd.hdf
AMSR_E_L3_MonthlyOcean_X##_yyyymm.hdf
```

Table 5. Values for the File Name Variables

| 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 |
| 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 6. Variable Values for the Product Maturity Code

| Variables | 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. |

Table 7. 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 8  provides examples of file name extensions for related files that further describe or supplement data files.

Table 8. 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 Spatial Information

### 1.3.1 Coverage

Spatial coverage is confined to global oceans and seas between 89.24°N and 89.24°S. See the AMSR-E Pole Hole web page for a description of holes that occur at the North and South Poles. The swath width is 1445 km for Level-2B data.

### 1.3.2 Resolution

Table 9 summarizes the various resolutions of the Level-2B ocean products. These resolutions are mapped to a 0.25-degree x 0.25-degree modeling grid in the Level-3 daily, weekly, and monthly products.

Table 9. Resolution Definitions for the Level-2B product

| Resolution Name | Level-2A Antenna Pattern | Spatial Resolution | Level-2B Ocean Products |
|---|---|---|---|
| Very low | 6.9 GHz | 56 km | SST |
| Low | 10.7 GHz | 38 km | Near-surface wind speed |
| Medium | 18.7 GHz | 21 km | Columnar water vapor |
| High | 36.5 GHz | 12 km | Columnar cloud liquid water |

### 1.3.3 Grid Description

The Level-3 grids are 720 rows by 1440 columns. Cell spacing is 0.25 degrees x 0.25 degrees. Due to contamination caused by parts of the Aqua spacecraft entering the field of view, the first (right-most) 14 pixels of each swath are excluded in the generation of the Level-3 ocean products. Users should note that the 14 edge pixels are included in the Level-2B ocean product.

## 1.4 Temporal Information

### 1.4.1 Coverage

AE_Ocean - 19 June 2002 to 3 October 2011

AE_DyOcn - 19 June 2002 to 3 October 2011

AE_WkOcn - 19 June 2002 to 2 October 2011

AE_MoOcn - 19 June 2002 to 1 October 2011

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

### 1.4.2 Resolution

Each Level-2B granule spans approximately 50 minutes. The Level-3 products include daily, weekly, and monthly resolutions.

# 2 DATA ACQUISITION AND PROCESSING

## 2.1 Background

The Level-2B ocean product algorithm is based on the physical Radiative Transfer Model (RTM) described in (Wentz and Meissner 2000). The RTM consists of an atmospheric absorption model for water vapor, oxygen, liquid cloud water, and a sea surface emissivity model that parameterizes the emissivity as a function of sea surface temperature, sea surface salinity, sea surface wind speed, and direction. Some components of the model were updated in recent versions of the algorithm including the dielectric constant of sea and cloud water (Meissner and Wentz 2004), the isotropic wind induced sea surface emissivity (Meissner and Wentz 2006), and the wind directional signal of the sea surface emissivity (Meissner and Wentz 2002) and (Meissner and Wentz 2006).

Between 4 and 11 GHz, the vertically polarized brightness temperature of the sea-surface has an appreciable sensitivity to SST. For example, at the AMSR-E frequency of 6.9 GHz, the derivative of the v-pol brightness temperature with respect to SST is about 0.5 (Wentz and Meissner 2007). This sensitivity is the basis for microwave SST retrievals. In addition to SST, brightness temperature depends on the sea-surface roughness and on the atmospheric temperature and moisture profile. Note that sea-surface roughness, which is tightly correlated with the local wind, is usually parameterized in terms of the near-surface wind speed and direction. Fortunately, the spectral and polarimetric signatures of the surface-roughness and the atmosphere are quite distinct from the SST signature, and the influence of these effects can be determined and retrieved given simultaneous observations at multiple frequencies and polarizations. AMSR-E has 10 channels corresponding to five frequencies (6.9, 10.7, 18.7, 23.8, and 36.5 GHz) and two polarizations (v-pol and h-pol), which are more than sufficient to separate the SST, wind, and atmosphere signals (vapor, cloud, and rain).

## 2.2 Acquisition

See the AMSR-E Instrument Description document.

## 2.3 Processing

### 2.3.1 Derivation Techniques and Algorithms

The ocean product retrievals are performed through a set of two-stage regression algorithms. The first stage is a set of regressions trained with global data. The first-stage retrievals provide reasonably good estimates of SST, wind, vapor, and cloud liquid water. However, because of the non-linear relationships between brightness temperature and the geophysical parameters, the retrievals coming from the global regressions are not optimal. In the second stage, a set of regressions that have been specially trained for a localized range of environmental conditions in the neighborhood of the first-stage retrievals is used.

The SST and wind speed algorithms are essentially the same. The only real difference is that the SST algorithm uses all 10 AMSR-E lower channels, while the wind algorithm does not use the 6.9 GHz channels because the 6.9 GHz channel does not significantly improve the wind retrievals; thus, by not using it, wind retrievals can be obtained at a higher spatial resolution. The columnar water vapor and columnar liquid cloud water algorithms also have a similar structure. These two algorithms only use the 18.7, 23.9, and 36.5 GHz channels.

#### 2.3.1.1 Training of the SST and Wind Algorithm

The algorithm regression coefficients are found by generating a large ensemble of simulated brightness temperatures computed from a microwave RTM for the ocean and intervening atmosphere (Wentz and Meissner 2000). The simulation is based on a set of 42,195 radiosonde soundings launched from weather ships and small islands around the globe (Wentz 1997). These soundings are used to specify the atmospheric part of the RTM. A cloud layer of various columnar liquid cloud water densities ranging from 0 mm to 0.3 mm and various cloud bottom and top heights between 500 m and 2500 m is superimposed over the soundings. For each sounding, a large range of the sea-surface conditions is considered. The sea-surface wind speed is varied from 0 to 40 m/s. The sea-surface temperature is varied ± 5.5°C about the Reynolds SST for the island site. For each of these Earth scenes, the RTM computes a set of 10 AMSR-E brightness temperatures, and then noise is added to the brightness temperature to replicate sensor noise.

The simulated brightness temperatures are used in a regression equation relating SST and wind to the brightness temperatures, and the regression coefficients are found via the standard least squares method, which minimizes the variance between the SST and wind value given by the regression equation and the true SST and wind value. Once the first-stage algorithms are specified, training of the second-stage algorithms can be performed. In this case, regression coefficients for 1444 separated algorithms are found, again using standard least squares. Each algorithm is trained using just a small subset of the Earth scenes that have a SST and wind value near the algorithm's reference SST/wind.

#### 2.3.1.2 Correction for Wind Direction Signal

The surface emissivity as well as the brightness temperature in each channel depends on wind direction relative to the looking azimuth. The wind direction signal grows with wind speed and reaches up to 3 K peak to peak amplitude above 10 m/s (Meissner and Wentz 2002) and (Meissner and Wentz 2006). This leads to a significant error in the retrieved SST and wind and a crosstalk between the accuracy error of the SST and wind retrievals and relative wind direction. In order to correct for the wind direction signal, the algorithm training is performed separately for a discrete set of 19 values for relative wind directions between 0 degrees and 360 degrees in 20-degree steps. For the final processing, the forecast is substituted by the Global Data Assimilation Systems (GDAS) of the National Centers for Environmental Prediction (NCEP) analysis. The regression coefficients are linearly interpolated from the 19 reference values of the discrete wind directions to the actual NCEP wind direction.

#### 2.3.1.3 Earth Incidence Variations

The surface emissivity also depends on the Earth Incidence Angle (EIA). Due to the oblateness of the Earth the EIA can deviate by about ±0.5 degrees from the nominal EIA of 55 degrees over the course of an AMSR-E orbit. The method to compensate for the variation in EIA is similar to the method to compensate for the wind direction effect. The SST and wind algorithms are trained for five discrete values of EIA that are taken in 0.5-degree steps around the nominal EIA of 55 degrees. In the retrievals, the regression coefficients are then linearly interpolated from the discrete set to the actual value of the EIA.

#### 2.3.1.4 Salinity Correction

All regressions are trained using a reference ocean surface salinity S of 35 ppt when computing the ocean surface emissivity. In order to accommodate the variability of the ocean salinity, a similar procedure is followed like what was done for the variations in relative wind direction and EIA. Because ocean salinity is a slow varying function of time and location, it is somewhat simpler to correct the measured AMSR-E brightness temperature to the reference salinity before doing the retrieval. Precompute a brightness temperature - correction climatology atlas for each channel at a discrete set of locations (latitude and longitude) and times (month of the year). For the calculation salinity values from the National Oceanagraphic Data Center (NODC) World Ocean Atlas, SST values from the Reynolds climatology, and typical values for the other geophysical parameters, such as wind speed, water vapor, and liquid cloud water, are used. In the retrievals, the brightness temperature correction values are linearly interpolated in location and time to the actual values of the AMSR-E measurement.

#### 2.3.1.5 Radio Frequency Interference (RFI) Corrections

Radio Frequency Interference (RFI) from a variety of sources has been identified as an ongoing and increasing source of contamination affecting channels 10.7 GHz and 18.7 GHz (both h-pol and v-pol) during the descending pass of the AMSR-E satellite. Beginning with the launch of AMSR-E in 2002, RFI from the Hotbird and Astra satellites was identified as the primary source of contamination in the 10.7 GHz channel. A flag was then implemented to identify and exclude the impacted observations, such as swath and wind data at low geostationary RFI angles.

Since 2007, interference due to HDTV broadcasting activities has been identified as the primary source of RFI, which impacts the AMSR-E 18.7 GHz channel. The locations of interference are geometrically consistent with geosynchronous satellite signals reflecting off the ocean surface into AMSR-E's field of view, and the timing of the interference is coincident with the launch of HDTV satellites, such as DirecTV-10 in 2007 and DirecTV-11 in 2008. In addition, spot beams used by HDTV satellites to serve different local programming to different local markets (and thus reuse the same set of frequencies), have resulted in amplified RFI. Since spot beams cover nearly the entire U.S. coastline, data users should be aware that AMSR-E ocean products derived from descending 18.7 GHz observations are potentially impacted along all U.S. coastal waters from September 2007 forward. As RFI interference continues to be an issue, updates to the science algorithm to flag and exclude all sources of RFI contamination are ongoing. In addition, the AMSR-E ocean products now include an RFI angle grid as a parameter for determining glint angles. (RSS 2010)

For a summary of algorithm changes since the start of the mission, refer to the AMSR-E Data Versions web page. For more details regarding RFI affecting AMSR-E, visit the RSS Radio Frequency Interference (RFI) web page.

### 2.3.2 Processing Steps

Separate processing steps compute Level-2B ocean products using different input Level-2A brightness temperatures.

1. Compute low-resolution (56 km) SST using all channels except 89.5 GHz.
2. Compute medium-resolution (21 km) wind speed and SST using 10.7 GHz, 18.7 GHz, 23.8 GHz and 36.5 GHz channels. The 21 km resolution SST is a special product that is only useful when the SST is above 15 degrees C. In order to compute wind speed, this step requires SST retrieval from step 1.
3. Retrieve columnar water vapor and liquid water, using the 18.7 GHz, 23.8 GHz, and 36.5 GHz channels. This step requires SST and wind estimates from steps 1and 2. High-resolution wind speed is computed as a special product.
4. Compute cloud liquid water from the 36.5 GHz channel. Retrievals are used as an indicator of rain in the next processing step. The retrieval algorithm requires estimates of SST, wind speed, and columnar water vapor from the first three steps.
5. The final step is to perform rain flagging. The rain-flag module searches for rain within the low-, medium-, and high-resolution footprints. A cloud liquid water threshold of 0.18 mm is used to indicate rain. The amount of rain in each of the three footprints is determined, and the appropriate flag is set.

Note: Due to contamination caused by parts of the Aqua spacecraft entering the field of view, the first (right-most) 14 pixels of each swath are excluded in the generation of the Level-3 ocean products. Users should note that the 14 edge pixels are included in the Level-2B ocean product.

Level-3 gridded products are generated from the Level-2B swath data using a drop in the bucket method. A .25 x .25-degree Earth grid is established. All valid swath observations for the given time period (daily, weekly, or monthly) whose center latitude and longitude fall within a given grid cell are averaged, and the resulting mean value is recorded for that grid cell.

Swath data values are flagged and excluded:

- due to rain
- over and near sea ice
- at low sun glint angles
- at low geostationary Radio Frequency Interference (RFI) angles (descending passes only)
- SST is excluded because of high wind speed (> 20 m/s)

Wind data values are flagged and excluded:

- due to rain
- over and near sea ice
- at low sun glint angles
- at low geostationary RFI angles (descending passes only)

Water Vapor is excluded due to heavy rain and over sea ice. Cloud Liquid Water is excluded over sea ice.

## 2.4 Quality, Errors, and Limitations

### 2.4.1 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).

### 2.4.2 Automatic QA

Information in this section is taken from Conway (2002). Surface types and brightness temperatures are examined for land, sea ice, and other sources of contamination. Ocean variables are not calculated for these areas. For all variables, values that are out of range are not included. Instead, the resulting product pixel indicates an out-of-range condition.

The Level-2B ocean files contain three data elements related to quality assurance: the Scan_quality_flag, the Ocean_summary_quality_flag, and the Ocean_products_quality_flag.

Note: When a bit is said to be set, its value is 1.

#### 2.4.2.1 Scan Quality Flag

The Scan_quality_flag collection pertains to all observations of a scan. Each bit of the flag indicates a particular condition for the scan as described in Table 10.

Table 10. Scan Quality Flag Bit Condition for Setting the Flag

| Bit | Parameter | Condition for Setting the Flag |
|---|---|---|
| 0 | Scan Summary | This reflects the condition of all the other bits in the Scan_quality_flag. If any other bit is set, then the summary flag is set. The summary flag does not describe those characteristics that apply only to a single Level-1A or Leve-l2A channel. |
| 1 | Antenna Spin Rate | Spin rate is out of range. |
| 2 | Navigation | Position or velocity of the Navigation_data for the scan is zero. |
| 3 | Orbit Radius | Distance of the satellite to the Earth's center is outside an acceptable range. |
| 4 | Observations | At least one of the observation locations fail to fall on the Earth. |
| 5 | Attitude | Either the roll, pitch, or yaw exceeds two degrees. |
| 6 | Hot Load Thermistors | The median filtering and averaging process does not yield an acceptable result. The result may be unacceptable because the number of measurements within the tolerance window is too small, or because the mean of the measurements within the tolerance window is out of range. |
| 7-31 | n/a | n/a |

#### 2.4.2.2 Ocean Summary Quality Flag

The Ocean_summary_quality_flag indicates one of several conditions for each scan. In the event that more than one of the conditions are true, the flag will contain the lowest numerical value of the conditions that are true.

Table 11. Ocean Summary Quality Flag Values

| Value | Definition |
|---|---|
| 0 | Good scan |
| 1 | Bad calibration data |
| 2 | Bad scan as identified by the scan summary bit in the Scan_quality_flag |
| 3 | Bad time information based on Level-2A san summary flag |

### 2.4.2.3 Ocean Products Quality Flag

The Ocean_products_quality_flag is an array of six bytes for each observation of each scan.

**Byte One**

The first byte of the Ocean_products_quality_flag describes the possibility of ice based on climatology, and the general plausibility of the observed brightness temperatures.

Table 12. Byte One of the Ocean Products Quality Flag

| Bit | Condition for Setting the Flag |
|---|---|
| 0 | Sea ice is possible based on monthly climatology. |
| 1 | The AMSR-E $T_b$s indicate sea ice. |
| 2 | The very-low resolution $T_b$s are out of bounds or missing. No retrieval is done. |
| 3 | The low resolution $T_b$s are out of bounds or missing. No retrieval is done. |
| 4 | The medium resolution $T_b$s are out of bounds or missing. No retrieval is done. |
| 5 | The high resolution $T_b$s are out of bounds or missing. No retrieval is done. |
| 6-7 | n/a |

**Byte Two**

The second byte of the Ocean_products_quality_flag describes the acceptability of products at a given resolution. Refer to the Table 9 table for definitions of very low, low, medium, and high.

Table 13. Byte Two of the Ocean Products Quality Flag

| Bit | Resolution | Value | Definition |
|---|---|---|---|
| 0-1 | Very low | 0 | Normal retrieval |
| 2-3 | Low | 1 | Retrieval out-of-bounds |
| 4-5 | Medium | 2 | No retrieval |
| 6-7 | High | | |

**Byte Three**

The third byte of the Ocean_products_quality_flag is determined by the proximity and intensity of rain. Microwave SST and wind speed measurements become unreliable in rain. Users should examine the quality flags contained in the product and discard SST or wind speed data if necessary, to avoid rain contamination. This set of flags allows a user to choose an acceptable level of rain contamination for SST and wind products. The lowest bit allows the most observations and the most rain contamination. Each of the higher bits allows progressively less observations, some of which might have been acceptable. Very light rain in the following table is defined as less than 0.18 mm of cloud liquid water. Light rain ranges from approximately 0.18 mm to 0.35 mm of cloud liquid water. The exact range varies according to geography.

Table 14. Byte Three of the Ocean Products Quality Flag

| Value | Definition |
|---|---|
| 0 | No rain contamination |
| 16 | Light rain in cell |
| 20 | Light rain within 25 km of cell |
| 24 | Very light rain within 25 km of cell |
| 30 | Light rain within 40 km of cell |
| 31 | Very light rain within 40 km of cell |

**Byte Four**

The fourth byte of the Ocean_products_quality_flag indicates the surface type based on the fraction of land for three different spatial resolutions.

Table 15. Byte Four of the Ocean Products Quality Flag

| Bit | Resolution | Value | Definition |
|---|---|---|---|
| 0-1 | Very low | 0 | 0 to 0.2% |
| 2-3 | Low | 1 | 0.2% to 1.4% land |
| 4-5 | Medium | 2 | More than 1.4% land |
| 6-7 | n/a | | |

**Byte Five**

The fifth byte of the Ocean_products_quality_flag is an unsigned integer representing the sun glint angle, which is the angle between the spacecraft viewing vector and the sun's specular reflection vector. This parameter uses a scale factor of 0.5 and an offset of 0. Because of the possibility of clipping, an angle of 127.5 should be interpreted as 127.5 degrees or greater.

**Byte Six**

The sixth byte of the Ocean_products_quality_flag is an unsigned integer representing the RFI glint angle, which is the angle between the spacecraft viewing vector and the geostationary satellite specular RFI reflection vector. This parameter uses a scale factor of 0.5 and an offset of 0. Because of the possibility of clipping, an angle of 127.5 should be interpreted as 127.5 degrees or greater.

Level-3 automatic QA procedures involve simply evaluating the Level-2B quality flags to determine if observations are valid for Level-3 products.

### 2.4.3 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

### 2.4.4 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 RSS to GHCC along with associated granule information, where they are converted to HDF raster images prior to delivery to NSIDC.

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

## 2.5 Error Sources

Wind direction variability is the dominant source of error in SST retrieval if the brightness temperature wind direction signal is large. The 6.9 GHz and 10.7 GHz channels are sensitive to SST; however, they have the potential for wind direction variability. Atmospheric interference at 6.9 GHz is very small and easily removed using higher-frequency channels.

The following estimates of retrieval errors are preliminary; further validation will be conducted to redefine the errors (Wentz and Meissner 2000):

Table 16. Preliminary Retrieval Error Estimates

| Variable | Root-Mean-Square (RMS) Error |
|---|---|
| SST | 0.58° C |
| Wind speed | 0.86 m/s |
| Columnar water vapor | 0.57 mm |
| Columnar cloud liquid water | 0.017 mm |

AMSR-E has a cold mirror for calibration purposes which inadvertently enters the instrument field of view. This contamination, which comes from other parts of the spacecraft as well, most significantly affects the 6.9 GHz frequency followed by the 10.7 GHz frequency due to their large fields of view. The affect of the cold contamination is dependent on the specific channels and algorithm being used. To reduce the affects in the Level-3 ocean products, the first (right-most) 14 pixels of each swath are excluded from processing. Users should note, the 14 edge pixels are included in the Level-2B ocean product.

# 3 VERSION HISTORY

See the AMSR-E | Version History web page for a summary of algorithm changes since the start of mission.

# 4 CONTACTS AND ACKNOWLEDGMENTS

**Frank Wentz and Thomas Meissner**
Remote Sensing Systems (RSS)

# 5 REFERENCES

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

Meissner, Thomas and Frank J. Wentz. 2004. The Complex Dielectric Constant of Pure and Sea Water from Microwave Satellite Observations. *IEEE TGARS* 42(9): 1836 – 1849.

Meissner, Thomas and Frank J. Wentz. 2006. Ocean Retrievals for WindSat: Radiative Transfer Model, Algorithm, Validation. CD with proceedings of the 9th Specialist Meeting on Microwave Radiometry and Remote Sensing Applications. San Juan, Puerto Rico, 28 February – 03 March 2006. *IEEE Catalog no*. 06EX1174C.

Meissner, Thomas and Frank J. Wentz. 2002. Analysis of the Ocean Surface Wind Direction Signal in Passive Microwave Brightness Temperatures. *IEEE TGARS* 40(6): 1230 – 1240.

Remote Sensing Systems (RSS). "Radio Frequency Interference (RFI)." Sources of RFI for AMSR-E. [2010].

Wentz, F. J., and T. Meissner. 2007. Supplement 1 Algorithm Theoretical Basis Document for AMSR-E Ocean Algorithms. Santa Rosa, California USA: Remote Sensing Systems. (PDF file, 177 KB)

Wentz, F. and T. Meissner. 2000. AMSR Ocean Algorithm. Algorithm Theoretical Basis Document, Version 2. Santa Rosa, California USA: Remote Sensing Systems.

Wentz, Frank J. 1997. A Well-calibrated Ocean Algorithm for SSM/I. *Journal of Geophy. Res* 102: 8703 – 8718.

To see a list of publications that have utlized NSIDC's AMSR-E data, see the AMSR-E Data-Related Publications web page.

# 6 DOCUMENT INFORMATION

## 6.1 Publication Date

March 2004

## 6.2 Date Last Updated

20 April 2021