

AIRS
Level 1C Product User Guide

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1. PURPOSE OF THE DOCUMENT

The purpose of this document is to give users of AIRS data a brief guide how to load and use the AIRS L1C products in their research. L1C is a level of processing beyond L1B, transforming a collection of radiances into a spectrum. The L1C data remove instrument artifacts caused by calibration errors, bad channels, spectral shifts, spectral gaps and spectral overlaps.

1.1 Overview of the AIRS L1C data

The AIRS Infrared (IR) level 1C data set contains AIRS infrared calibrated and geolocated radiances in $W/m^2/micron/ster$. This data set is generated from AIRS level 1B data. The spectral coverage of L1C data is from 3.74 to 15.4 μm . The nominal spectral resolution $\lambda/\Delta\lambda = 1200$. The spectrum is sampled twice per spectral resolution element in a total of 2645 spectral channels. A day of AIRS data is divided into 240 granules (scenes) each of 6-minute duration. For the AIRS IR measurements, an individual granule contains 135 pixels across-track and 90 along-track pixels; there are total of $135 \times 90 = 12,150$ pixels per granule.

AIRS employs a 49.5 degree crosstrack scanning with a 1.1 degree instantaneous field of view (IFOV) to provide twice daily coverage of essentially the entire globe in a 1:30 PM sun synchronous orbit with the $13.5 \times 13.5 km^2$ spatial resolution at nadir.

The L1C swath products are derived from the L1B swath products. The primary purpose of the level 1C is to generate the spectra of radiances without spectral gaps caused by the instrument design and bad spectral points. The AIRS L1C data can be used for comparative (with other IR measurements) studies and for weather-climate research.

1.2 Definitions

GSFC DISC Goddard Earth Sciences Data and Information Services Center

L1B AIRS Level-1B radiances in 2378 channels

L1C AIRS Level-1C radiances in 2645 channels

1.3 L1C Data Description

The data are in HDF-EOS format and can be read using any HDF-EOS tool or library. Matlab and IDL readers are available at <http://disc.sci.gsfc.nasa.gov>. The data is provided in granule files including observations made over a period of 6 minutes. Each Level-1C file contains one swath named "L1C_AIRS_Science". Each data swath has three main characteristics: dimensions, attributes and data fields. The dimension set describes the physical limits or boundaries of the data as a series of directions and scale (i.e., maximum number of points on a side). The attributes of a data swath describe the data collection circumstances of a data swath (e.g., time, latitude/longitude

for each scan). For a 6.0 minute granule file, the AIRS swaths each contain 135 scans per granule file.

Definitions for key parameters are given below. The full description can be found in Appendix 2.

Name	Type	Dimensions	Explanation
radiances	32-bit floating-point	Channel (= 2645)	Radiances for each channel in milliWatts/m**2/cm**-1/steradian
L1cProc	8-bit unsigned integer	Channel (= 2645)	Bit field, by channel, for the current spectrum. Zero means the channel was unchanged in Level-1C.; Bit 7 (MSB, value 128): This is a synthesized fill channel where the AIRS instrument does not have a detector; Bit 6: (value 64) Cleaned. See L1cCleanReason for the cause; Bit 5: (value 32) Shifted frequency (not used in release 6.0); Bit 4: (value 16) radiometric correction applied (not used in release 6.0); Bit 3: (value 8) unused/reserved (value 0); Bit 2: (value 4) unused/reserved (value 0); Bit 1: (value 2) unused/reserved (value 0); Bit 0: (LSB, value 1) Output value is a dummy/filler value because data is missing or otherwise could not be processed.

Name	Type	Dimensions	Explanation
L1cSynthReason	8-bit unsigned integer	Channel (= 2645)	<p>0: value is preserved from Level-1B;</p> <p>1: Filled because this channel falls in a gap between AIRS instrument modules;</p> <p>2: Cleaned because this channel is known to be of low quality;</p> <p>3: Cleaned because of bad (-9999.0) Level-1B radiance value;</p> <p>4: Cleaned because of high Level-1B NeN noise measurement;</p> <p>5: Cleaned because Level-1B reported a zero or negative value in the NeN noise measurement indicating that the channel is in too poor a state for noise level to be measured effectively;</p> <p>6: Cleaned because the telemetry, gain, offset, or pop flag bits were set in Level-1B CalFlag (not used);</p> <p>7: Cleaned because Level-1B radiance is unphysically hot;</p> <p>8: Cleaned because Level-1B radiance is unphysically cold;</p> <p>9: Cleaned because Level-1B radiance is hotter than expected based on the radiances of correlated channels;</p> <p>10: Cleaned because Level-1B radiance is colder than expected based on the radiances of correlated channels;</p> <p>11: Cleaned because Level-1B radiance is significantly increased by scene spatial inhomogeneity;</p> <p>12: Cleaned because Level-1B radiance is significantly decreased by scene spatial inhomogeneity;</p> <p>100: Cleaned by runtime user command (Test mode only)</p>
NeN	32-bit floating-point	Channel (= 2645)	Noise-equivalent Radiance (radiance units) for an assumed 250 K scene. Channels which have synthesized radiances will have a flag value of 999.0.
Inhomo850	32-bit floating-point	None	Brightness temperature difference for the adjacent edges of the M-08 and M-09 detector modules. (frequency near 850 cm ⁻¹) This is a double difference using a PC reconstructed spectrum. Absolute values over ~0.84 indicate likely impact from spatial scene inhomogeneity (K)

2. L1C DATA ACCESS AND USE

2.1 Accessing the Data

AIRS L1C data are processed and archived at the NASA Goddard Earth Sciences Data and Services Center (GES DISC), <http://disc.sci.gsfc.nasa.gov>. In addition to observed spectra, Level 1C data also contain temporal, spatial, solar, and viewing geometry parameters, quality flags, and extensive quality assurance information.

Maps of AIRS granules for every day of the Aqua mission can be found at:

https://airs11.ecs.nasa.gov/Aqua_AIRS_Level1/AIRXAMAP.005/.

The lead person to contact is Evan Manning at Evan.M.Manning@jpl.nasa.gov. For more information about the algorithms involved in the production of the L1C data see the reference Manning et al., 2014.

2.2 Examples of Usage

Each granule file contains a set of 2645 frequencies, latitudes (90 x 135), longitudes (90 x 135), and radiances (2645 x 90 x 135). Figure 1 shows an example for a granule #71 in January 1, 2006.

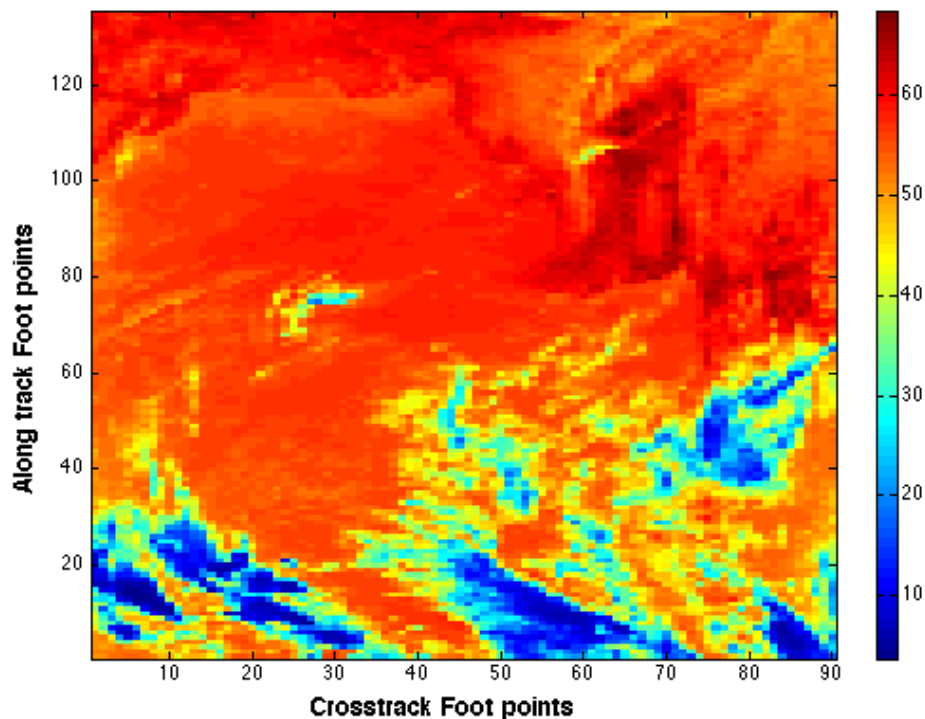


Figure 1. The L1C radiance for the granule AIRS.2006.01.01.071.L1C.AIRS_Rad.v6.1.0.0.G14091182311.hdf (granule number 71 in January 1, 2006) in the window channel 1231 nm. The colorbar shows radiance in $\text{mW/m}^2/\text{micron/sr}$.

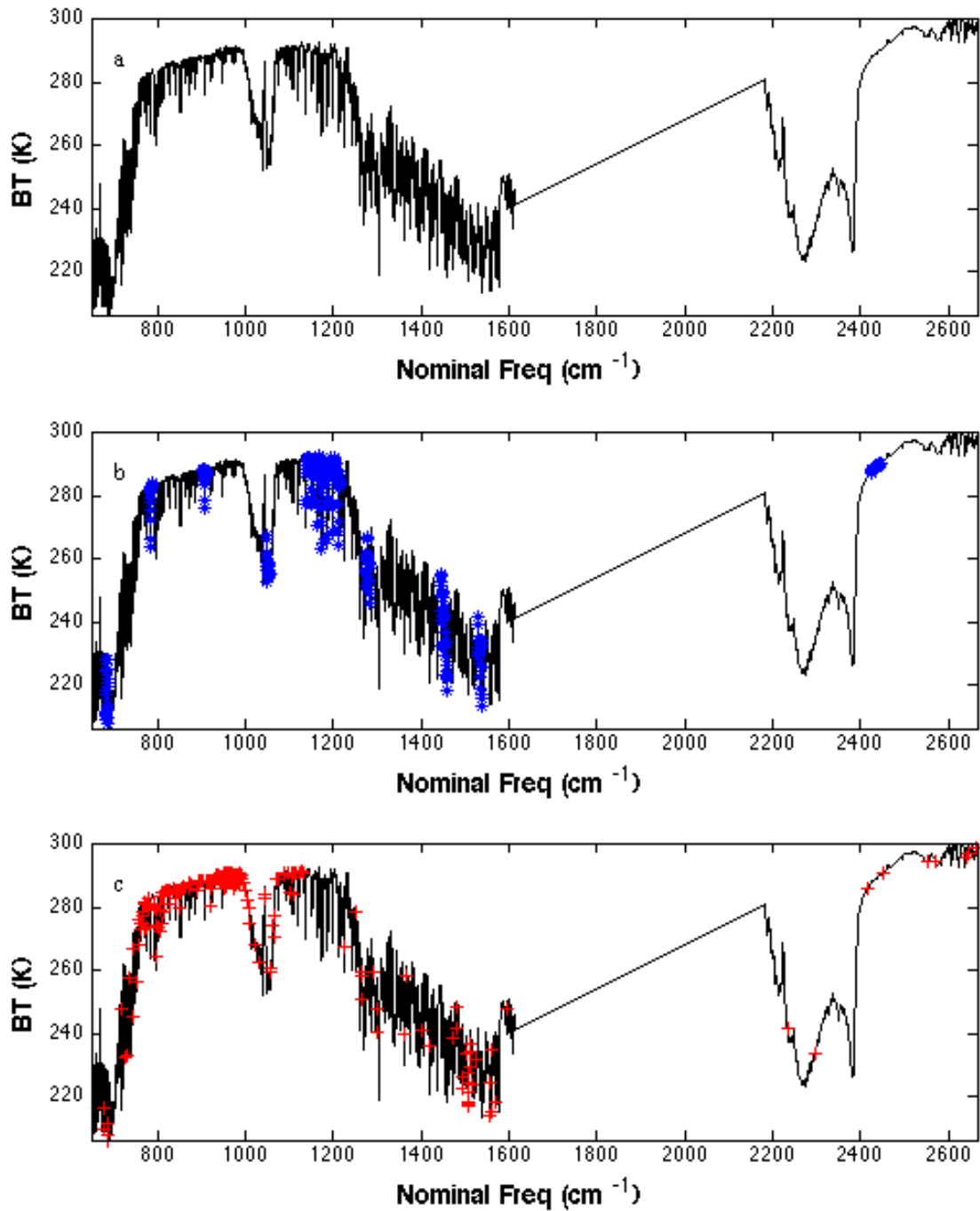


Figure 2. (a) Spectrum of the low-left corner footprint for the granule shown in Figure 1. (b) The same spectrum with filled channels marked by blue asterisks. (c) The red pluses mark the channels on the spectrum shown in (a) that are cleaned from L1B spectra.

2.3 Recommendations to Users

This product is recommended for studies that require a use of the L1 data without spectral gaps. A user should carefully read and take into account the limitations, which come due to the interpolation processing. However some NIST traceability is lost in L1C, so climate users may prefer to use L1B. See Appendix 1 for more information.

3. REFERENCES

Manning, E. M., L1C Status & Plans, Presentation at the AIRS meeting, Nov. 28, 2012. Available at:

<https://airs.jpl.nasa.gov/resources/presentations>

AIRS Level-1C Algorithm Theoretical Basis Document (ATBD), Manning et al., 2015, available at:

http://eospso.gsfc.nasa.gov/sites/default/files/atbd/V6.1.0_201_AIRS_L1C_ATBD.pdf

AIRS v6.1 Released Files Description

APPENDIX 1. AIRS v6.1.0 Level-1C Limitations and Caveats

1. Introduction

Version 6.1.0 is the initial release of the AIRS L1C product. However there are important limitations to its use. The AIRS Level-1C (L1C) product makes AIRS radiances much easier to use than the Level-1B (L1B) product. It eliminates most gaps in the spectral coverage and furnishes synthesized radiances where the AIRS instrument either provides no measurement or provides low quality data. The AIRS Level-1C Algorithm Theoretical Basis Document (L1C ATBD) gives full details on this process.

2. Changes from L1B to L1C

Users who come to AIRS L1C after using AIRS L1B should be aware of these differences:

2.1 L1C has a different number of channels than L1B

Where AIRS L1B has 2378 channels, AIRS L1C expands the list to 2645 channels by creating synthesized channels in instrument gaps. Some overlap channels are also eliminated. Attempting to read 2645-element L1C fields into arrays sized for 2378-element fields will cause problems.

L1C has the following fields to help use the 2645 channel set:

- **nominal_freq** – Gives the frequencies for each of the 2645 L1C channels. (Note: L1B also has a field named **nominal_freq**. The L1B **nominal_freq** field gives the frequencies of the 2378 channels in L1B; the L1C **nominal_freq** gives the frequencies of the 2645 channels in L1C.)
- **ChanID** – Gives the L1B channel indices for each of the 2645 L1C channels.
- **ChanMapL1b** – Gives the L1C channel indices for each of the 2378 L1B channels.

Details can be found in the L1C interface specification.

2.2 L1C provides a value of NeN per spectrum

L1B reports noise with a single 1-dimensional **NeN** array per six-minute granule. L1C provides one noise measurement per channel per spectrum, thus the **NeN** is now a 3-dimension quantity with dimensions 2645 channels * 90 footprints * 135 scan lines. The noise reported for each channel throughout the granule will take on only 2 possible values:

- 1) Where the channel radiance is preserved from L1b, the L1B **NeN** is repeated in L1C
- 2) Where the channel radiance is replaced with a synthesized value, **NeN** will have flag value 999.0

NeN is always set to 999.0 for channels that are always synthesized because they fall in a gap in L1B spectral coverage or because the detector is of very low quality.

2.3 L1C provides different quality control (QC) information than L1B

AIRS documentation directs users of L1B to check the quality of the observations using a variety of QC sources including **NeN**, **CalFlag**, and the channel properties files.

L1C users can safely ignore QC completely and expect high quality radiances in every channel in every spectrum. But L1C also provides the revised **NeN** and a variety of other fields so users can be as selective as their application requires. The key fields are **L1cProc**, **L1cSynthReason**, and **Inhomo850**.

L1cProc has bits for each possible type of processing that could be applied. For the v6.1.0 L1C release, the only values used are:

- 0**: Radiance is preserved from L1B unchanged
- 64**: Cleaned. Radiance is synthesized because the l1b value may be of low quality.
- 128**: Filled. Radiance is synthesized because the AIRS instrument does not have a detector at this frequency.

For radiances that were synthesized (cleaned or filled), **L1cSynthReason** gives the reason. Details can be found in the L1C interface specification.

Inhomo850 provides a metric of how impacted a spectrum is by scene inhomogeneity.

3. Caveats for v6.1.0 of L1C

3.1 Limitations of synthesized radiances

The process of synthesizing radiances includes many trade-offs, detailed in the L1C ATBD. Users of the L1C product should be aware of some problem areas. For this discussion we divide synthetic radiances into 4 broad categories:

- 1) Gap channels
- 2) Frequently cleaned channels
- 3) Infrequently cleaned channels
- 4) Spatially misaligned channels

Each category has unique risks.

3.1.1 Gap channels

Gaps are spectral regions that fall between the physical detectors of the AIRS instrument. A simple algorithm is used to calculate the synthetic radiances in these cases, so they should never be treated as observations.

3.1.2 Frequently cleaned channels

Channels can be selected for regular cleaning based on **NeN** measured in L1B or other static quality factors. See the L1C ATBD for details. In these cases the synthesized radiances are of high quality but there is a risk that in some cases a synthesized radiance has replaced an observation that was of high quality. This can happen because noise values and static flagging emphasize worst-case behavior. A channel misbehaving $\frac{1}{4}$ of the time will be synthesized 100% of the time. In some cases channels might be replaced because they have a high **NeN** but may actually behave in a very Gaussian way, and so the original L1B would be preferable for certain analyses. Use the L1B if appropriate.

3.1.3 Infrequently synthesized channels

Channels can be selected for replacement infrequently because the measure radiance differs from the expected range as interpreted by a PC reconstruction. This process identifies and corrects wild values that may result from radiation hits or non-Gaussian instrument noise. But there is a risk that since not all possible real geophysical states are represented in the PC training set, some real observations are systematically excluded from L1C. Atmospheric SO₂ and CO and surface CaCO₃ are among the cases not represented. The L1C algorithm avoids replacing radiances where coherent groups of channels report radiances differing from the PC reconstruction, and in testing this preserves signals from SO₂, CO, and CaCO₃. There may be other cases that are not preserved, so users of specific channels should check for systematic exclusions.

3.1.4 Spatially misaligned channels

One subset of infrequently synthesized channels is those that are subject to distortion in cases of inhomogeneous scenes. Each channel measures a valid radiance, but because the different channels are viewing slightly different regions the L1B radiances taken together do not form a sensible spectrum. For example 2 channels which both view the surface might report brightness temperatures 1 K apart, because the viewing area of one includes slightly more clouds than the viewing area of the other. A program that interprets the difference as a difference in spectral surface emissivity between the two frequencies would give odd results for the individual spectrum. A statistical treatment of the same 2 channels over many scenes would still give an accurate mean because clouds are as likely to be on either side of the field of view.

Because many neighboring channels are all distorted together, the PC reconstruction can also be distorted in the same direction. This leads to lower-quality correction, especially for the most inhomogeneous scenes.

L1C includes an indicator so users can avoid the scenes most impacted by inhomogeneity. **Inhomo850** is an estimate in K of the distortion caused by inhomogeneity over the frequency range near 850 cm^{-1} . The L1C interface specification and ATBD give details. Because **Inhomo850** is measured over this specific frequency range, it is very powerful for that part of the spectrum but less effective elsewhere. It is very useful throughout the longwave to midwave spectral regions but only moderately useful for the shortwave region ($2180\text{-}2670\text{ cm}^{-1}$).

3.2 Uncorrected artifacts

The v6.1.0 release of L1C targets correction of specific L1B features at a coarse level. There are still residual errors in the corrected values and there are other features that are not addressed.

3.2.1 Residual errors from cleaning

Error characteristics of cleaned radiances are addressed in section 3.1 above. There is also a risk from channels that have anomalous radiances but are not cleaned.

One area of concern is errors that are small. Channels are corrected only if the expected error from not correcting them exceeds a threshold that varies depending on many circumstances in $[0.7, 4.0]\text{ K}$, generally 2 K . See the ATBD for details. Because errors are assumed to be approximately Gaussian, errors up to 4 K in a few uncorrected channels per spectrum should be expected.

The shortwave region ($2180\text{-}2670\text{ cm}^{-1}$) in particular has relatively poor reconstruction and so only the largest outliers are corrected.

There can also be rare cases where large outliers from radiation hits are allowed through the L1C process. L1C contains logic that lets unexpected values pass through if there appears to be a coherent structure of at least 2 neighboring channels. Rare radiation hits can be passed by this test, either because the radiation hit directly excites 2-3 channels or because the radiation hit happens to strike in a region where it coincides with background errors from the reconstruction.

3.2.2 Features that are not addressed by v6.1.0 L1C

L1C v6.1.0 does not address all errors in L1B. Radiometric errors and spectral shifts will be addressed in a future release.

There are known radiometric errors in AIRS L1B, and these carry through to L1C:

- Trends in the shortwave part of the spectrum
- M-08 A/B
- Overlap biases

AIRS L1B also has frequencies that vary slightly with time. A future version of L1C will adjust to compensate, essentially giving a fixed-frequency record. But v6.1.0 leaves observations at the original frequencies.

APPENDIX 2. L1C INTERFACE SPECIFICATION VERSION 6.1

Interface Specification Version 6.1.0.0

2014-10-20

ESDT ShortName = "AIRICRAD"

DOI = "10.5067/AQUA/AIRS/DATA101"

Swath Name = "L1C_AIRS_Science"

Level = "level1C"

Footprints = 90

scanlines per scanset = 3

Dimensions

These fields define all dimensions that can be used for HDF-EOS swath fields.

The names "GeoTrack" and "GeoXTrack" have a special meaning for this document: "Cross-Track" data fields have a hidden dimension of "GeoXTrack"; "Along-Track" data fields have a

Name	Value	Explanation
GeoXTrack	90	Dimension across track for footprint positions. Same as number of footprints per scanline. -- starting at the left and increasing towards the right as you look along the satellite's path
GeoTrack	# of scan lines in swath	Dimension along track for footprint positions. Same as number of scanlines in granule. Parallel to the satellite's path, increasing with time. (Nominally 45 for Level-2, AMSU-A, and AIRS/Vis low-rate engineering; 135 for AIRS/Vis and HSB high-rate quantities)
Channel	2645	Dimension of channel array (This list of channels removes the overlaps and fills the gaps found in the 2378-channel set from the AIRS instrument.)
L1bChannel	2378	Dimension of channel array used in L1B. (In this list channels are generally in order of increasing wavenumber, but because frequencies can vary and because all detectors from a physical array of detector elements (a "module") are always grouped together there are sometimes small reversals in frequency order where modules overlap.)

hidden dimension of "GeoTrack"; "Full Swath Data Fields have hidden dimensions of both "GeoTrack" and "GeoXTrack".

Geolocation Fields

These fields appear for every footprint (GeoTrack * GeoXTrack times) and correspond to footprint center coordinates and "shutter" time.

Name	Explanation
Latitude	Footprint boresight geodetic Latitude in degrees North (-90.0 ... 90.0)
Longitude	Footprint boresight geodetic Longitude in degrees East (-180.0 ... 180.0)
Time	Footprint "shutter" TAI Time: floating-point elapsed seconds since Jan 1, 1993

Attributes

These fields appear only once per granule and use the HDF-EOS "Attribute" interface

Name	Type	Explanation
processing_level	string of 8-bit characters	Zero-terminated character string denoting processing level ("level1C")
instrument	string of 8-bit characters	Zero-terminated character string denoting instrument ("AIRS")
DayNightFlag	string of 8-bit characters	Zero-terminated character string set to "Night" when the subsatellite points at the beginning and end of a granule are both experiencing night according to the "civil twilight" standard (center of refracted sun is below the horizon). It is set to "Day" when both are experiencing day, and "Both" when one is experiencing day and the other night. "NA" is used when a determination cannot be made.
AutomaticQAFlag	string of 8-bit characters	Zero-terminated character string denoting granule data quality: (Always "Passed", "Failed", or "Suspect")
NumTotalData	32-bit integer	Total number of expected scene footprints

Name	Type	Explanation
NumProcessData	32-bit integer	Number of scene footprints which are present and can be processed routinely (state = 0)
NumSpecialData	32-bit integer	Number of scene footprints which are present and can be processed only as a special test (state = 1)
NumBadData	32-bit integer	Number of scene footprints which are present but cannot be processed (state = 2)
NumMissingData	32-bit integer	Number of expected scene footprints which are not present (state = 3)
NumLandSurface	32-bit integer	Number of scene footprints for which the surface is more than 90% land
NumOceanSurface	32-bit integer	Number of scene footprints for which the surface is less than 10% land
node_type	string of 8-bit characters	Zero-terminated character string denoting whether granule is ascending, descending, or pole-crossing: ("Ascending" and "Descending" for entirely ascending or entirely descending granules, or "NorthPole" or "SouthPole" for pole-crossing granules. "NA" when determination cannot be made.)
start_year	32-bit integer	Year in which granule started, UTC (e.g. 1999)
start_month	32-bit integer	Month in which granule started, UTC (1 ... 12)
start_day	32-bit integer	Day of month in which granule started, UTC (1 ... 31)
start_hour	32-bit integer	Hour of day in which granule started, UTC (0 ... 23)
start_minute	32-bit integer	Minute of hour in which granule started, UTC (0 ... 59)
start_sec	32-bit floating-point	Second of minute in which granule started, UTC (0.0 ... 59.0)
start_orbit	32-bit integer	Orbit number of mission in which granule started
end_orbit	32-bit integer	Orbit number of mission in which granule ended

Name	Type	Explanation
orbit_path	32-bit integer	Orbit path of start orbit (1 ... 233 as defined by EOS project)
start_orbit_row	32-bit integer	Orbit row at start of granule (1 ... 248 as defined by EOS project)
end_orbit_row	32-bit integer	Orbit row at end of granule (1 ... 248 as defined by EOS project)
granule_number	32-bit integer	Number of granule within day (1 ... 240)
num_scansets	32-bit integer	Number of scansets in granule (1 ... 45)
num_scanlines	32-bit integer	Number of scanlines in granule (3 * num_scansets)
start_Latitude	64-bit floating-point	Geodetic Latitude of spacecraft at start of granule (subsattellite location at midpoint of first scan) in degrees North (-90.0 ... 90.0)
start_Longitude	64-bit floating-point	Geodetic Longitude of spacecraft at start of granule (subsattellite location at midpoint of first scan) in degrees East (-180.0 ... 180.0)
start_Time	64-bit floating-point	TAI Time at start of granule (floating-point elapsed seconds since start of 1993)
end_Latitude	64-bit floating-point	Geodetic Latitude of spacecraft at end of granule (subsattellite location at midpoint of last scan) in degrees North (-90.0 ... 90.0)
end_Longitude	64-bit floating-point	Geodetic Longitude of spacecraft at end of granule (subsattellite location at midpoint of last scan) in degrees East (-180.0 ... 180.0)
end_Time	64-bit floating-point	TAI Time at end of granule (floating-point elapsed seconds since start of 1993)
eq_x_longitude	32-bit floating-point	Longitude of spacecraft at southward equator crossing nearest granule start in degrees East (-180.0 ... 180.0)
eq_x_tai	64-bit floating-point	Time of eq_x_longitude in TAI units (floating-point elapsed seconds since start of 1993)

Name	Type	Explanation
LonGranuleCen	16-bit integer	Geodetic Longitude of the center of the granule in degrees East (-180 ... 180)
LatGranuleCen	16-bit integer	Geodetic Latitude of the center of the granule in degrees North (-90 ... 90)
LocTimeGranuleCen	16-bit integer	Local solar time at the center of the granule in minutes past midnight (0 ... 1439)
num_fpe	16-bit integer	Number of floating point errors
orbitgeoqa	32-bit unsigned integer	See Released Files Description
num_satgeoqa	16-bit integer	Number of scans with problems in satgeoqa
num_glintgeoqa	16-bit integer	Number of scans with problems in glintgeoqa
num_moongeoqa	16-bit integer	Number of scans with problems in moongeoqa
num_ftptgeoqa	16-bit integer	Number of footprints with problems in ftptgeoqa
num_zengeoqa	16-bit integer	Number of footprints with problems in zengeoqa
num_demgeoqa	16-bit integer	Number of footprints with problems in demgeoqa
Rdiff_swindow_M1a_chan	16-bit integer	Array M1a channel used as one reference in calculating Rdiff_swindow. (index into radiance & frequency arrays 1...2378)
Rdiff_swindow_M2a_chan	16-bit integer	Array M2a channel used as one reference in calculating Rdiff_swindow. (index into radiance & frequency arrays 1...2378)
Rdiff_lwindow_M8_chan	16-bit integer	Array M8 channel used as one reference in calculating Rdiff_lwindow. (index into radiance & frequency arrays 1...2378)
Rdiff_lwindow_M9_chan	16-bit integer	Array M9 channel used as one reference in calculating Rdiff_lwindow. (index into radiance & frequency arrays 1...2378)

Name	Type	Explanation
		1...2378)
CF_Version	string of 8-bit characters	Cloud Filter Version Identification. Identifies the set of thresholds used in determination of spectral_clear_indicator.
NumSaturatedFOVs	16-bit unsigned integer	Number of scene fields-of-view (out of a nominal 1350) in which the downlinked counts overflowed.
NumUnderflowFOVs	16-bit unsigned integer	Number of scene fields-of-view (out of a nominal 1350) in which the downlinked counts underflowed.
NumCalFOVsOutOfBounds	16-bit unsigned integer	Number of calibration fields-of-view (out of a nominal 810) in which the downlinked counts underflowed or overflowed.
NumSO2FOVs	16-bit unsigned integer	Number of fields-of-view (out of a nominal 1350) with a significant SO2 concentration based on the value of BT_diff_SO2.
granules_present	string of 8-bit characters	Zero-terminated character string denoting which adjacent granules were available for smoothing ("All" for both previous & next, "Prev" for previous but not next, "Next" for next but not previous, "None" for neither previous nor next)

Per-Granule Data Fields

These fields appear only once per granule and use the HDF-EOS "Field" interface

Name	Type	Extra Dimensions	Explanation
nominal_freq	32-bit floating-point	Channel (= 2645)	Nominal frequencies (cm ⁻¹) of each channel
ChanID	16-bit unsigned integer	Channel (= 2645)	A unique identifier for each channel. For those channels which are present in Level-1B this identifier is identical to the 1-based index of the channel in Level-1B. For channels which are addidn in Level-1C to fill gaps in the Level-1B record, this is a unique identifier with value > 2378. Note: ChanID are not sequential.
ChanMapL1b	16-bit	L1bChannel	A map from the 2378-channel Level-1B channel set into the 2645-channel Level-1C set. For Level-1B channels which are

Name	Type	Extra Dimensions	Explanation
	integer	(= 2378)	used in Level-1C, this will be a number in [1,2645] giving the 1-based index in the Level-1C list for this channel. For Level-1B channels which are not used in Level-1C, this will be -1.
L1cNumSynth	32-bit unsigned integer	Channel (= 2645)	A count of how many spectra in the granule have synthesized values (cleaned or filled) for each channel. Fill channels will always have value 12150 (=90*135)

Along-Track Data Fields

These fields appear once per scanline (GeoTrack times)

Name	Type	Extra Dimensions	Explanation
satheight	32-bit floating-point	None	Satellite altitude at nadirTAI in km above reference ellipsoid (e.g. 725.2)
satroll	32-bit floating-point	None	Satellite attitude roll angle at nadirTAI (-180.0 ... 180.0 angle about the +x (roll) ORB axis, +x axis is positively oriented in the direction of orbital flight completing an orthogonal triad with y and z.)
satpitch	32-bit floating-point	None	Satellite attitude pitch angle at nadirTAI (-180.0 ... 180.0 angle about +y (pitch) ORB axis. +y axis is oriented normal to the orbit plane with the positive sense opposite to that of the orbit's angular momentum vector H.)
satyaw	32-bit floating-point	None	Satellite attitude yaw angle at nadirTAI (-180.0 ... 180.0 angle about +z (yaw) axis. +z axis is positively oriented Earthward parallel to the satellite radius vector R from the spacecraft center of mass to the center of the Earth.)
glintlat	32-bit floating-point	None	Solar glint geodetic latitude in degrees North at nadirTAI (-90.0 ... 90.0)
glintlon	32-bit floating-point	None	Solar glint geodetic longitude in degrees East at nadirTAI (-180.0 ... 180.0)
nadirTAI	64-bit floating-point	None	TAI time at which instrument is nominally looking directly down. (between footprints 15 & 16 for AMSU or between footprints 45 & 46 for AIRS/Vis & HSB) (floating-point elapsed seconds since start of 1993)

Name	Type	Extra Dimensions	Explanation
sat_lat	64-bit floating-point	None	Satellite geodetic latitude in degrees North (-90.0 ... 90.0)
sat_lon	64-bit floating-point	None	Satellite geodetic longitude in degrees East (-180.0 ... 180.0)
scan_node_type	8-bit integer	None	'A' for ascending, 'D' for descending, 'E' when an error is encountered in trying to determine a value.
satgeoqa	32-bit unsigned integer	None	See Released Files Description
glintgeoqa	16-bit unsigned integer	None	See Released Files Description
moongoqa	16-bit unsigned integer	None	See Released Files Description

Full Swath Data Fields

These fields appear for every footprint of every scanline in the granule (GeoTrack * GeoXTrack times)

Name	Type	Extra Dimensions	Explanation
radiances	32-bit floating-point	Channel (= 2645)	Radiances for each channel in milliWatts/m**2/cm**-1/steradian
scanang	32-bit floating-point	None	Scanning angle of AIRS instrument with respect to the AIRS Instrument for this footprint (-180.0 ... 180.0, negative at start of scan, 0 at nadir)
satzen	32-bit floating-point	None	Spacecraft zenith angle (0.0 ... 180.0) degrees from zenith (measured relative to the geodetic vertical on the reference (WGS84) spheroid and including corrections outlined in EOS SDP toolkit for normal accuracy.)
satazi	32-bit floating-	None	Spacecraft azimuth angle (-180.0 ... 180.0) degrees E of

Name	Type	Extra Dimensions	Explanation
	point		N GEO)
solzen	32-bit floating-point	None	Solar zenith angle (0.0 ... 180.0) degrees from zenith (measured relative to the geodetic vertical on the reference (WGS84) spheroid and including corrections outlined in EOS SDP toolkit for normal accuracy.)
solazi	32-bit floating-point	None	Solar azimuth angle (-180.0 ... 180.0) degrees E of N GEO)
sun_glint_distance	16-bit integer	None	Distance (km) from footprint center to location of the sun glint (-9999 for unknown, 30000 for no glint visible because spacecraft is in Earth's shadow)
topog	32-bit floating-point	None	Mean topography in meters above reference ellipsoid
topog_err	32-bit floating-point	None	Error estimate for topog
landFrac	32-bit floating-point	None	Fraction of spot that is land (0.0 ... 1.0)
landFrac_err	32-bit floating-point	None	Error estimate for landFrac
ftptgeoqa	32-bit unsigned integer	None	See Released Files Description
zengeoqa	16-bit unsigned integer	None	See Released Files Description
demgeoqa	16-bit unsigned integer	None	See Released Files Description
state	32-bit integer	None	Data state: 0:Process, 1:Special, 2:Erroneous, 3:Missing
Rdiff_swindow	32-bit floating-	None	Radiance difference in the 2560 cm ⁻¹ window region used to warn of possible errors caused by scene non-uniformity and misalignment of the beams:

Name	Type	Extra Dimensions	Explanation
	point		radiance(Rdiff_swindow_M1a_chan) - radiance(Rdiff_swindow_M2a_chan). (radiance units)
Rdiff_lwindow	32-bit floating-point	None	Radiance difference in the longwave window(850 cm ⁻¹ -1) used to warn of possible errors caused by scene non-uniformity and misalignment of the beams: radiance(Rdiff_lwindow_M8_chan) - radiance(Rdiff_lwindow_M9_chan). (radiance units)
SceneInhomogeneous	8-bit unsigned integer	None	Threshold test for scene inhomogeneity, using band-overlap detectors (bit fields); Bit 7 (MSB, value 128): scene is inhomogeneous, as determined by the Rdiff_swindow threshold. For v5.0 the test is $\text{abs}(\text{Rdiff_swindow}) > 5 * \sqrt{\text{NeN}(\text{Rdiff_swindow_M1a_chan})^2 + \text{NeN}(\text{Rdiff_swindow_M2a_chan})}$; Bit 6 (value 64): scene is inhomogeneous, as determined by the Rdiff_lwindow threshold. For v5.0 the test is $\text{abs}(\text{Rdiff_lwindow}) > 5 * \sqrt{\text{NeN}(\text{Rdiff_lwindow_M8_chan})^2 + \text{NeN}(\text{Rdiff_lwindow_M9_chan})}$; Bits 5-0: unused (reserved)
dust_flag	16-bit integer	None	Flag telling whether dust was detected in this scene; 1: Dust detected; 0: Dust not detected; -1: Dust test not valid because of land; -2: Dust test not valid because of high latitude; -3: Dust test not valid because of suspected cloud; -4: Dust test not valid because of bad input data
dust_score	16-bit integer	None	Dust score. Each bit results from a different test comparing radiances. Higher scores indicate more certainty of dust present. Dust probable when score is over 380. Not valid when dust_flag is negative.
spectral_clear_indicator	16-bit integer	None	Flag telling whether scene was flagged as clear by a spectral filter. Only ocean filter is validated; 2: Ocean test applied and scene identified as clear; 1: Ocean test applied and scene not identified as clear; 0: Calculation could not be completed. Possibly some inputs were missing or FOV is on coast or on the edge of a scan or granule; -1: Unvalidated land test applied and scene not identified as clear; -2: Unvalidated land test applied and scene identified as clear
BT_diff_SO2	32-bit floating-	None	Brightness temperature difference Tb(1361.44 cm ⁻¹) - Tb(1433.06 cm ⁻¹) used as an indicator of SO2 release

Name	Type	Extra Dimensions	Explanation
	point		from volcanoes. Values under -6 K have likely volcanic SO ₂ . (Kelvins)
AB_Weight	8-bit integer	Channel (= 2645)	A/B detector weights; -1: Channel radiance is an approximate value synthesized by cleaning or filling; 0: A weight = B weight; 1: A side only; 2: B side only
L1cProc	8-bit unsigned integer	Channel (= 2645)	Bit field, by channel, for the current spectrum. Zero means the channel was unchanged in Level-1C.; Bit 7 (MSB, value 128): This is a synthesized fill channel where the AIRS instrument does not have a detector; Bit 6: (value 64) Cleaned. See L1cCleanReason for the cause; Bit 5: (value 32) Shifted frequency (not used in release 6.0); Bit 4: (value 16) radiometric correction applied (not used in release 6.0); Bit 3: (value 8) unused/reserved (value 0); Bit 2: (value 4) unused/reserved (value 0); Bit 1: (value 2) unused/reserved (value 0); Bit 0: (LSB, value 1) Output value is a dummy/filler value because data is missing or otherwise could not be processed.
L1cSynthReason	8-bit unsigned integer	Channel (= 2645)	0: value is preserved from Level-1B; 1: Filled because this channel falls in a gap between AIRS instrument modules; 2: Cleaned because this channel is known to be of low quality; 3: Cleaned because of bad (-9999.0) Level-1B radiance value; 4: Cleaned because of high Level-1B NeN noise measurement; 5: Cleaned because Level-1B reported a zero or negative value in the NeN noise measurement indicating that the channel is in too poor a state for noise level to be measured effectively; 6: Cleaned because the telemetry, gain, offset, or pop flag bits were set in Level-1B CalFlag (not used); 7: Cleaned because Level-1B radiance is unphysically hot; 8: Cleaned because Level-1B radiance is unphysically cold; 9: Cleaned because Level-1B radiance is hotter than expected based on the radiances of correlated channels; 10: Cleaned because Level-1B radiance is colder than expected based on the radiances of correlated

Name	Type	Extra Dimensions	Explanation
			channels; 11: Cleaned because Level-1B radiance is significantly increased by scene spatial inhomogeneity; 12: Cleaned because Level-1B radiance is significantly decreased by scene spatial inhomogeneity; 100: Cleaned by runtime user command (Test mode only)
NeN	32-bit floating-point	Channel (= 2645)	Noise-equivalent Radiance (radiance units) for an assumed 250 K scene. Channels which have synthesized radiances will have a flag value of 999.0.
Inhomo850	32-bit floating-point	None	Brightness temperature difference for the adjacent edges of the M-08 and M-09 detector modules. (frequency near 850 cm ⁻¹) This is a double difference using a PC reconstructed spectrum. Absolute values over ~0.84 indicate likely impact from spatial scene inhomogeneity (K)