README Document for

AIRS Level-1B Calibration Subset Product (AIRXBCAL)

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Revision History

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9/27/2007	Initial version	Jason Li
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README Document

AIRS Level-1B Version 005 Calibration Subset Product

AIRXBCAL

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Introduction

This document applies to the Atmospheric Infrared Sounder (AIRS) Calibration Subset Product (AIRXBCAL). The Calibration Subset Product aids in verifying the calibration of AIRS, AMSU and VIS channel radiances relative to truth on the Earth's surface. Each file covers a 24-hour period from midnight to midnight UTC, and for certain spots during that day extracts AIRS IR and VIS radiances, AMSU-A brightness temperatures, and AVN predicted sea surface temperatures. AMSU-A data are interpolated to the location of the AIRS footprint. For the VIS data, only the mean and the standard deviation of the 8x9 pixel grid are saved.

Figure 1: Calibration sites. Polar sites are not shown in this figure.

AIRS science team continues to improve the data processing algorithm. At the end of each development cycle, a new version of the algorithm is delivered to NASA GES DISC for forward processing, as well as reprocessing of historical data. Currently, version 5.0.16.0 (or simply referred to as Version 5) data is available to the public and the first product file for AIRS Level-1B Calibration Subset Product starts on 2002-08-31 00:00:00 UTC.

1.1 AIRS Instrument Description

1.1.1 AIRS

AIRS is a continuously operating cross-track scanning sounder, consisting of a telescope that feeds an echelle spectrometer. Figure 2 shows the cutaway drawing of the AIRS instrument. The AIRS infrared spectrometer acquires 2378 spectral samples at resolutions, $\lambda/\Delta\lambda$, ranging from 1086 to 1570, in three bands: 3.74 μm to 4.61 μm, 6.20 μm to 8.22 μm, and 8.8 μm to 15.4 μm. The spatial footprint of the infrared channels is 1.1° in diameter, which corresponds to about 13.5x13.5 km in the nadir. The instrument characteristics are listed in table 1.

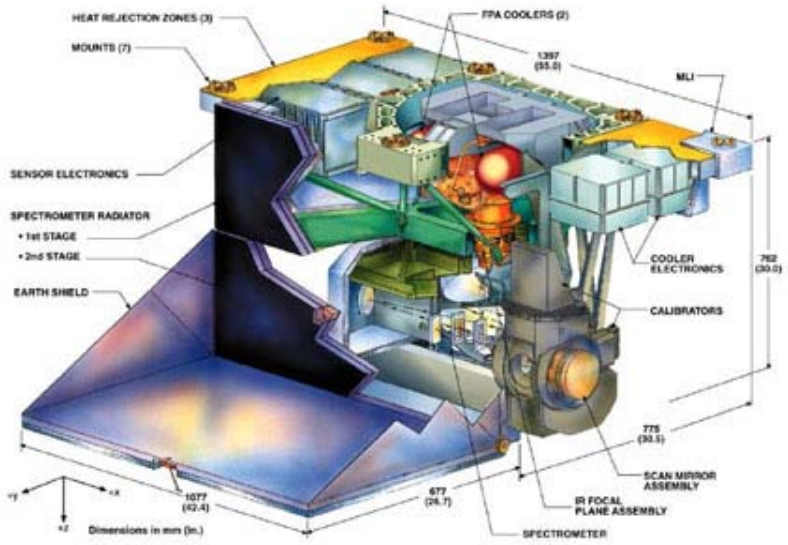

Figure 2. AIRS instrument cutaway drawing.

During each scan, the rotating external mirror scans the underlying Earth scene from 49° on one side of the nadir to 49° on the other side, in 90 integration periods, and provides two views of dark space (one before and one after the Earth scene), one view of an internal radiometric calibration target, and one view of an internal spectral calibration target. Thus each scan produces 94 sets of measurements (90 earth scenes and 4 calibrations). The scan is repeated every 8/3 seconds. The downlink data rate from the AIRS instrument is 1.2 Mbit/sec.

The IR focal plane is cooled to about 58 K by a Stirling/pulse tube cryocooler. The scan antenna operates at approximately 265 K due to radiative coupling to the Earth and space and to the 150 K IR spectrometer. Cooling of the IR optics and detectors is necessary to achieve the required instrument sensitivity.

Table 1. AIRS Specifications

Instrument Type	Multi-aperture, non-Littrow echelle array grating spectrometer.
Infrared Spectral Coverage	3.74 - 4.61 μm 6.20 - 8.22 μm 8.80 - 15.4 μm
Spectral Response	$\lambda/\Delta\lambda > 1200$ nominal
Spectral Resolution	$\Delta\lambda/2$
Spectral Sampling	1 $\Delta\lambda$
Integrated Response (95%)	0.05 $\Delta\lambda$ 24 hours
Wavelength Stability	0.01 $\Delta\lambda$
Scan Angle	±49.5° around nadir
Swath Width	1650 km nominal
Instantaneous Field of View (IFOV)	1.1°
Measurement Simultaneity	>99%
Sensitivity (NEDT)	0.14 K at 4.2 μm 0.20 K from 3.7 - 13.6 μm 0.35 K from 13.6 - 15.4 μm
Radiometric Calibration	±3% absolute error

1.1.2 AIRS Vis/NIR

AIRS has four Vis/NIR channels. Channel 1 (0.40 to 0.44 μm) is designed to be most sensitive to aerosols. Channels 2 (0.58 to 0.68 μm) and 3 (0.71 to 0.92 μm) approximate the response of AVHRR channels 1 and 2, respectively, and are particularly useful for surface studies. Channel 4 has a broadband response (0.49 to 0.94 μm) and can be used for energy balance studies. The VIS/NIR channels help to account for the effect of low-level clouds. The infrared and microwave channels sometimes have difficulty distinguishing low clouds from the surface. A photometric reference source is provided for calibration of the VIS/NIR channels.

The VIS/NIR channels have nominally six times the spatial resolution of the IR Sensor Assembly. Each IR footprint of the AIRS instrument is associated with a 9x8 array of Vis/NIR pixels. A single across-track scan of AIRS (90 IR footprints) corresponds to a Vis/NIR image of 720 pixels across-track, and 9 pixels along-track. The across-track pixels overlap with their neighbors by ~1/3 of a pixel on each side. In the along-track direction, successive scan-lines overlap by 1.57 pixels.

Table 2. AIRS Vis/NIR Specifications

Instrument Type	Photometer boresighted to the the AIRS spectrometer
Spectral Coverage	0.41 - 0.44 μm 0.58 - 0.68 μm 0.71 - 0.92 μm 0.49 - 0.94 μm
Scan Angle	±49.5°
Instantaneous Field of View (IFOV)	0.185°
SNR @ albedo = 0.4	> 100
Polarization	< 0.5%

1.1.3 AMSU-A

AMSU-A (as seen in Figure 2) primarily provides temperature soundings. It is a 15-channel microwave temperature sounder implemented as two independently operated modules. Module 1 (AMSU-A1) has 12 channels in the 50-58 GHz oxygen absorption band which provide the primary temperature sounding capabilities and 1 channel at 89 GHz which provides surface and moisture information. Module 2 (AMSU-A2) has 2 channels: one at 23.8 GHz and one at 31.4 GHz which provide surface and moisture information (total precipitable water and cloud liquid water). Like AIRS, AMSU-A is a cross-track scanner. The three receiving antennas, two for AMSU-A1 and one for AMSU-A2, are parabolic focusing reflectors that are mounted on a scan axis at a 45° Tilt angle, so that radiation is reflected from a direction along the scan axis (a 90° reflection). AMSU-A scans three times as slowly as AIRS (once per 8 seconds) and its footprints are approximately three times as large as those of AIRS (45 km at nadir). This result in three AIRS scans per AMSU-A scans and nine AIRS footprints per AMSU-A footprint.

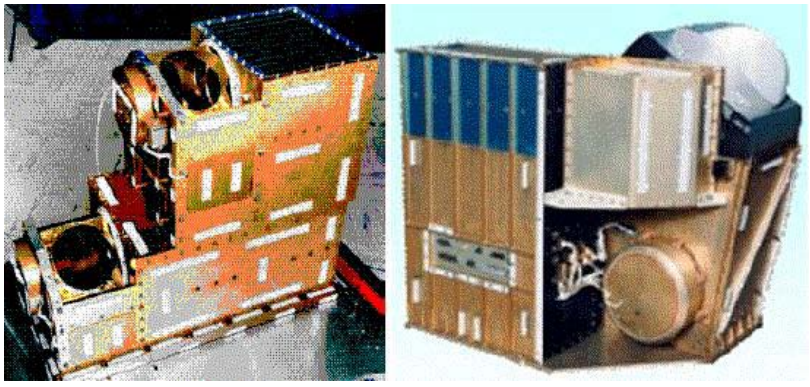

Figure 2. View of AMSU-A1 (left) and AMSU-A2 right.

Table 3. AMSU instrument characteristics

	AMSU-A1	AMSU-A2
Data Rate	1.3 kbits/s	0.4 kbits/s
Antenna Size	15 cm (2 units)	31 cm (1unit)
Instantaneous Field of View (IFOV)	3.3°	3.3°
Swath Width	100; 1650 km	100; 1650 km
Pointing Accuracy	0.2°	0.2°
Number of Channels	13	2

Sensor	Channel	Central Frequency (GHz)	Bandwidth (MHz)	Sensitivity NEDT (K)
AMSU-A2	1	23.8	280	0.3
	2	31.4	180	0.3
AMSU-A1	1	50.300	180	0.4
	2	52.800	400	0.25
	3	53.596±0.115	170	0.25
	4	54.400	400	0.25
	5	54.940	400	0.25
	6	55.500	330	0.25
	7	57.290344 = Flo	330	0.25
	8	Flo±0.217	78	0.4
	9	Flo±0.3222 (±0.048)	36	0.4
	10	Flo±0.3222 (±0.022)	16	0.6
	11	Flo±0.3222 (±0.010)	8	0.8
	12	Flo±0.3222 (±0.0045)	3	1.2
	13	89.000	6000	0.5

1.2 Background on Algorithm

Please refer to the Calibration Subset Quick Start document for details.

The file contains information associated with AIRS footprints selected if they match any of the following criteria:

- A footprint is determined to be cloud-free according to a series of tests.
- The center of a footprint lies within 30 nautical miles of one of 20 calibration sites. The sites were chosen for a diversity of local and provide continuous atmospheric and surface observations. Key sites are Dome Concordia, Antarctica Automatic Weather Station (AWS 8989), ARM-Cart sites at Southern Great Plains and North Slope Alaska and Tropical Western Pacific, French SPOT desert calibration site in Egypt, AMSR-E tropical rainforest site in Boumba Cameroon, and Surgut, Siberia.
- A footprint contains very high clouds and is within $|\text{lat}| \leq 60°$.

In addition, isolated near-nadir footprints are selected at random in such a way that a globally balanced coverage is achieved. (Regular sampling would over-represent Polar regions).

For additional information on how the sst1231s are derived, please consult Dr. George Aumann's AIRS science team presentation material, titled AIRS SST Measurements, 25 February 2003.

2. Data Organization

2.1 Granularity

Each file contains data between 00:00:00.000 UTC and 23:59:59.999 of an UTC day. There is one data file per UTC calendar day.

2.2 Filenaming Convention

The AIRS Level-2 standard product files are named in accordance to the following convention:

AIRS.*yyyy***.***mm***.***dd***.L1B.Cal_Subset.v***m.m.r.b.***productionTimeStamp***.hdf**

Where:

- yyyy = 4 digit year number [2002 -].
- mm = 2 digit month number [01-12]
- dd = day of month [01-31]
- m.m.r.b = algorithm version identifier is made up of major version, minor version, release version and build number respectively.
- productionTimeStamp = file creation time stamp. Starts off with a letter G for GES DISC processing facility, followed by yydddhhmmss.
  - yy: year number without century;
  - ddd: day of a year [1-366];
  - hhmmss: hours, minutes and seconds UTC time.

Filename example: AIRS.2007.01.02.L1B.Cal_Subset.v5.0.16.0.G07194052626.hdf

2.3 File Format and Structure

AIRS Level-1B Calibration Subset product files are stored in the HDF-EOS4 format. HDF-EOS4 format is an extension of the HDF4 format (developed by NCSA) to meet the needs of EOS data products. These extensions facilitate the creation of grid, point and swath data structures, in the case of AIRS Level-1B Calibration Subset product, it is of the swath type structure. When working with HDF/HDF-EOS files, one is not concerned with exactly how the data are stored physically; rather you interact with the data file by knowing the identifiers (filename, swath names, parameter names, attribute names etc)

and through a set of application programming interface (APIs) methods. Among five categories of methods, the access methods, basic I/O methods and inquiry methods are relevant for reading the data[1].

Please note that this calibration subset product, although stored in swath structure, is not a true "swath" of complete scans, each containing a fixed number of footprints. Instead, individual footprints are selected, in time order, from scans covering multiple granules. Each calibration subset file contains two data swaths: L1B_AIRS_Cal_Subset and L1B_AIRS_Cal_Subset_Gran_Stats. A swath is made up of four major HDF-EOS data groups: dimensions, geolocation fields, attributes and data fields. The HDF-EOS programming interface provides information query function calls on all four groups. The content inside each group is detailed in the data contents section.

2.4 Key Science Data Fields

The key data fields are the ones most likely to be use by users. The complete list of all fields can be found in the next section. The L1B_AIRS_Cal_Subset swath contains the bulk of science data, while as the L1B_AIRS_Cal_Subset_Gran_Stats contains a number of statistics on a per-granule basis. In the L1B_AIRS_Cal_Subset swath,

- *reason*: identifies the reason for the footprint's selection.
- *site*: if a footprint is selected near a calibration site, then this field is site ID code.
- *radiances* / *VisMean* / *amsu_bt*: AIRS IR radiances, Visible/NIR radiances, and AMSU brightness temperatures.
- *avnsst*: sea surface temperature derived from the nearest (in time) two of the six 3-hour AVN forecasts.
- *cx*:* spatial coherence tests, five of them.
- *dust_flag:* indicate if dust is detected
- *BT_diff_SO2:* brightness temperature differences between 1361.44 cm^{-1} and 1433.06 cm^{-1} to indicate SO_2 release from volcanoes.

[1] See section 4.3 for more details.

3. Data Contents

3.1 Dimensions

Table 4a. L1B_AIRS_Cal_Subset Dimensions

Name	Value	Description
GeoTrack	Variable	The number of CalSubset footprints contained in swath L1B_AIRS_Cal_Subset (equal to attribute *fp_count*).
IR_Channel	2378	The number of AIRS IR channels. Frequencies are given in field *nominal_freq*.
VIS_Channel	3	The number of VIS channels. Channel 1: ~0.4 micron Channel 2: ~0.6 micron Channel 3: ~0.8 micron (The VIS/NIR instrument also has a 4th broadband channel, but that is not used here.)
AMSU_Channel	15	The number of AMSU-A channels. Channel 1: 23.8 GHz Channel 2: 31.4 GHz Channel 3: 50.3 GHz Channel 4: 52.8 GHz Channel 5: 53.596 ± 0.115 GHz Channel 6: 54.4 GHz Channel 7: 54.94 GHz Channel 8: 55.5 GHz Channel 9: f0 Channel 10: f0 ± 0.217 GHz; Channel 11: f0 ±df ±48 MHz Channel 12: f0 ± df ± 22 MHz Channel 13: f0 ± df ± 10 MHz Channel 14: f0 ± df ±4.5 MHz Channel 15: 89 GHz f0 = 57290.344 MHz df = 322.4 MHz

Table 4b. L1B_AIRS_Cal_Subset_Gran_Stats Dimensions

Name	Value	Description
Gransproc	241	The number of granules per day, plus 1.
IR_Channel	2378	The number of AIRS IR channels. Frequencies are given in field *nominal_freq*.
VIS_Channel	3	The number of VIS channels. Channel 1: ~0.4 micron Channel 2: ~0.6 micron Channel 3: ~0.8 micron (The VIS/NIR instrument also has a 4th broadband channel, but that is not used here.)
AMSU_Channel	15	The number of AMSU-A channels. Channel 1: 23.8 GHz Channel 2: 31.4 GHz Channel 3: 50.3 GHz Channel 4: 52.8 GHz Channel 5: 53.596 ± 0.115 GHz

		Channel 6: 54.4 GHz Channel 7: 54.94 GHz Channel 8: 55.5 GHz Channel 9: f0 Channel 10: f0 ± 0.217 GHz; Channel 11: f0 ±df ±48 MHz Channel 12: f0 ± df ± 22 MHz Channel 13: f0 ± df ± 10 MHz Channel 14: f0 ± df ±4.5 MHz Channel 15: 89 GHz f0 = 57290.344 MHz df = 322.4 MHz

3.2 Geolocation Fields

Table 5. L1B_AIRS_Cal_Subset Geolocation Fields

Name	DESCRIPTION
Latitude	Footprint boresight geodetic Latitude in degrees North (-90.0 ... 90.0); 64-bit float
Longitude	Footprint boresight geodetic Longitude in degrees East (-180.0 ... 180.0); 64-bit float
Time	Footprint "shutter" TAI Time: floating-point elapsed seconds since Jan 1, 1993; 64-bit float

L1B_AIRS_Cal_Subset_Gran_Stats swath contains no geolocation fields.

3.3 Swath Attributes

Table 6. L1B_AIRS_Cal_Subset Swath Attributes

NAME	DATA TYPE	DESCRIPTION
CF_Version	char-8	Cloud Filter Version Identification. Collectively identifies the set of thresholds used for cloud filtering and the distinction between day/night and land/water. The individual thresholds values are given in Table 6.
start_year	int-32	Start Year (eg. 2007). This field and the date and time fields following reflect the date/time of the earliest possible footprint that may be found in the output file.
start_month	int-32	Start Month (1-12)
start_day	int-32	Start Day of the Month (1-31)
start_hour	int-32	Start Hour
start_minute	int-32	Start Minute
start_sec	int-32	Start Second
fp_count	int-32	Footprint Count Total count of footprints
Clear	int-32	“Clear” Footprint Count. Count of footprints selected by the “cloud-free” thresholds (Selection Algorithm #1) - total for day/night and land/water
Clear_DL	int-32	“Clear” Footprint Count - day/land. The distinction between spacecraft day and spacecraft night is based on the solar zenith angle (the angle at the center of a footprint between zenith and the sun) and a day/night threshold angle (near 90°). The distinction between “land”, “water” and “coast” is based onset Quick Start the fraction of land (between 0.0 and 1.0) seen in a FOV and two threshold values (near 0.01 and 0.99). The threshold values are input

		arguments to the Clear Match PGE.
Clear_DW	int-32	“Clear” Footprint Count - day/water
Clear_NL	int-32	“Clear” Footprint Count – night/land
Clear_NW	int-32	“Clear” Footprint Count – night/water
CalSite	int-32	Calibration Site Footprint Count. Count of footprints selected from calibration sites (Selection Algorithm #2) - total for day/night and land/water
CalSite_DL	int-32	CalSite Footprint Count - day/land
CalSite_DW	int-32	CalSite Footprint Count - day/water
CalSite_NL	int-32	CalSite Footprint Count – night/land
CalSite_NW	int-32	CalSite Footprint Count - night/water
HiCloud	int-32	High Clouds Footprint Count; Count of footprints viewing high clouds over non-polar regions (Selection Algorithm #3) - total for day/night and land/water
HiCloud_DL	int-32	High Clouds Count - day/land
HiCloud_NL	int-32	High Clouds Count – night/land
HiCloud_DW	int-32	High Clouds Count – day/water
HiCloud_NW	int-32	High Clouds Count - night/water
Random	int-32	Random Footprint Count; Count of nadir footprints selected at random (Algorithm #4) - total for day/night and land/water (Actually only the center footprint of a 9-footprint “golfball” is selected at random. The surrounding 8 footprints are then set Quick Start added.)
Random_DL	int-32	Random Count - day/land
Random_DW	int-32	Random Count - day/water
Random_NL	int-32	Random Count - night/land
Random_NW	int-32	Random Count - night/water

L1B_AIRS_Cal_Subset_Gran_Stats swath contains no swath attributes.

3.4 Data Fields Appearing Once

Table 6a. L1B_AIRS_Cal_Subset Swath Data Fields

NAME	DATA TYPE	DIMENSION	DESCRIPTION
Nominal_freq	32-bit float	IR_Channel	Nominal IR channel frequencies (cm^{-1})

3.5 Along-Track Data Fields At Every Footprint

Table 7.1 L1B_AIRS_Cal_Subset Swath Data Fields

NAME	DATA TYPE	EXTRA DIMENSION	DESCRIPTION
granule_number	int-16	None	The granule from which the footprint was selected (range: 0 - 240). “0” identifies Granule 240 of the preceding day.
Scan	int-16	None	Scan number (range: 1 - 135)
footprint	int-16	None	Footprint number (range: 1 - 90)

reason	int-16	None	Footprint Selection Reason. Identifies the reason for the footprint's selection as follows: 1 = Clear (cloud-free) location 2 = Calibration site identified by field "site". 4 = High clouds 8 = Randomly selected location Note: Footprints may be selected for more than one reason. In that case the reason codes are combined (bitwise or'd).
Site	int-16	None	If the footprint was selected because it is near a calibration site (reason = 2), this field identifies the site as follows: 0 = footprint selection reason is not "calibration site" 1 = Egypt 1 Lat: 27.12°N, Lon: 026.10°E 2 = Simpson Desert Lat: 24.50°S, Lon: 137.00°E 3 = Dome Concordia Start Lat: 75.10°S, Lon: 123.40°E 4 = Mitu, Columbia Lat: 01.50°N, Lon: 069.50°W 5 = Boumba, Cameroon Lat: 03.50°N, Lon: 014.50°E 6 = Railroad Valley, NV Lat: 38.50°N, Lon: 115.70°W 7 = SPG/Arm-Cart, OK Lat: 36.60°N, Lon: 97.50°W 8 = Manus, Bismarck Archipelago Lat: 02.00°S, Lon: 147.40°E 9 = Nauru, Micronesia Lat: 00.50°S, Lon: 166.60°E 10 = North Pole Lat: 90.00°N, Lon: N/A 11 = South Pole Lat: 90.00°S, Lon: N/A 12 = Surgut, Siberian tundra Lat: 61.15°N Lon: 73.37°E 13 = Yunnan rain forest Lat: 23.90°N Lon:100.50°E 14 = Barrow, Alaska Lat: 71.32°N Lon:156.66°W 15 = Atqusuk, Alaska Lat: 70.32°N Lon:156.67°W 16 = Darwin, Australia Lat: 12.42°S Lon:130.89°E 17 = Lake Qinghai, China Lat: 36.75?N Lon:100.33?E 18 = Dunhuang, Gobi desert Lat: 40.17°N Lon: 94.33°E 19 = Lake Titicaca Lat: 15.88°S Lon: 69.33°W 20 = Lake Tahoe, CA Lat: 39.10°N Lon: 120.04°W
Scan_node_type	char	None	Node Type Consists of a single character: "A" = ascending node (day) "D" = descending node (night) "N" = north pole "S" = south pole "Z" = not available
satzen	float-32	None	Satellite Zenith Angle Angle between satellite and zenith at footprint location in degrees [0.0, 90.0] -9999.0 means "not available".
solzen	float-32	None	Solar Zenith Angle Angle between sun and zenith at footprint location in degrees [0 .0, 180.0]. -9999.0 means "not available".
topog	float-32	None	Mean elevation or "topography" at the center of the reference ellipsoid, in units of meters above mean sea level. -9999.0 means "not available".
satheight	float-32	None	Satellite altitude above nadir in km. -9999.0 means "not available".
Sun_glint_distance	int-16	None	Distance, in km, from footprint center to the location of the sun glint during the sunlit portion of the orbit. "30000" indicates the spacecraft is in the earth's shadow. -9999 means "not available".
LandFrac	float-32	None	Land Fraction. Fraction of surface identified to be land [0.0, 1.0]. -9999.0 means "not available".
radiances	float-32	IR_Channel	AIRS IR radiances for each channel for the selected footprint. Given in units of mW / m^2 / cm^{-1} / steradian -9999.0 means "not available".
VisMean	float-32	VIS_Channel	Mean Radiances - VIS Channels This is the mean of the 72 samples for VIS channels 1 - 3. Given in units of W / m^2 / µm / steradian. -9999.0 means "not available".
VisStdDev	float-32	VIS_Channel	Standard Deviation - VIS Channels This is the standard deviation of the 72 samples for VIS channels 1 - 3. -9999.0 means "not available".
avnsst	float-32	None	Sea Surface Temperature derived from the nearest (in time) two of six 3-hour Aviation Forecasts. The forecast times are T21Z of the previous day, T03Z, T09Z, T15Z, T21Z, and T03Z of the next day. The forecasts give the temperatures for a 1-degree grid. The derived temperature (K) is interpolated 1. for latitude 2. for longitude 3. for time

			-9999.0 means “not available”.
cx2616	float-32	None	Output of the spatial coherence test at 2616 cm^{-1}. For cloud-free data cx2616 < 0.7K over water and cx2616 < 2.0 K over land. -9999.0 means “not available”.
cx1231	float-32	None	Output of the spatial coherence test at 1231 cm^{-1}. Given in K. For cloud-free data cx1231 < 10.0 K -9999.0 means “not available”. See Note 1, below.
cx2395	float-32	None	Output of the spatial coherence test at 2395 cm^{-1} Given in K. -9999.0 means “not available”. See Note 1, below.
cxq2	float-32	None	Output of the spatial coherence test for total water vapor, using the bt2616 - bt2607 proxy Given in K. For cloud-free data cxq2 < 1.0 K -9999.0 means “not available”. See Note 1, below.
Cxlpn	float-32	None	Output of the spatial coherence test for the pseudo lapse rate lp, where: lp = (bt2395-bt2392) * (cos sza)0.3, where sza is the satellite zenith angle, Given in K. -9999.0 means “not available”. See Note 1, below.
bt1231	float-32	None	Brightness Temperature - 1231 cm-1 in K. -9999.0 means “not available”.
sst1231r5	float-32	None	Surface Temperature - 1231 cm^{-1}. This is the surface skin temperature (day and night) for surfaces with emissivity 0.98. This is a good approximation at 1231 cm-1 for non-frozen water, land surfaces covered by vegetation, snow and ice. Calculated per footprint as: sst1231r5 = bt1231 + 0.28 + (1.2 * q3) + (0.2962 * q3)2 + (1.0489 / cos(sza)) where: q3=bt1231-bt1227 and sza is the scan zenith angle. Given in K. -9999.0 means “not available”. Validated to 0.5K over liquid water.
lp2395clim	float-32	None	Pseudo lapse rate threshold applied in testing for cloud-free conditions.
amsu_bt	float-32	AMSU_Channel	AMSU-A antenna temperatures in K. (Note: When the AMSU-A L1B data set includes side-lobe corrected antenna temperatures, as planned for Version 5, this field will reflect those corrected temperatures.) -9999.0 means “not available”. Interpolated from 45 X 30 footprint AMSU-A swath to 135 X 90 footprint AIRS swath.
amsu_topog	float-32	None	Mean elevation or “topography”, in units of meters above mean sea level. -9999.0 means “not available”. Interpolated from 45 X 30 footprint AMSU-A swath to 135 X 90 footprint AIRS swath.
amsu_landFrac	float-32	None	Land Fraction. Fraction of surface identified to be land [0.0, 1.0]. -9999.0 means “not available”. Interpolated from 45 X 30 footprint AMSU-A swath to 135 X 90 footprint AIRS swath.
dust_flag	int16	None	Flag telling whether dust was detected in this scene; 1: Dust detected; 0: Dust not detected; -1: Invalid (due to land); -2: Invalid (due to high latitude); -3: Invalid (due to suspected cloud); -4: Invalid (due to bad input data)
BT_diff_SO2	float32	None	Brightness temperature difference BT(1361.44 cm^{-1}) - BT(1433.06 cm^{-1}) used as an indicator of SO2 release from volcanoes. Values under -6 K have likely volcanic SO2. -9999.0 means “not available”.

Descriptions for L1B_AIRS_Cal_Subset_Grans_Stats parameters are listed in table 7.2. The individual fields are collected from groups (second column) of individual footprints differentiated as follows:

- Group 1: includes all AIRS IR footprints in the input data stream that lie inside the data day and for which the state flag is “processed”.
- Group 2: include all AIRS footprints of Group 1 that also match day/night and land/water criteria established for the majority of a granule’s footprints.
- Group 2a: includes all footprints of Group 2 representing clear field of views.
- Group 2b: include all footprints of Group 2 representing high clouds.

For additional information, please consult AIRS/AMSU/HSB Version 5 Calibration Subset Quick Start.

Table 7.2 L1B_AIRS_Cal_Subset_Gran_Stats Swath Data Fields

NAME	GROUP TYPE	DATA TYPE	EXTRA DIMENSION	DESCRIPTION
center_latitude	1	float-64	None	Latitude of granule center (-90 to 90).
center_longitude	1	float-64	None	Longitude of granule center (-180 to 180).
mean_day_flag	1	int-16	None	Indicates whether the majority of AIRS footprints in the input data stream lies on the day or night side. 0 = night 1 = day -1 = unknown Note that this flag refers to footprints examined in the input data stream not footprints included in the output data stream (i.e. this file).
mean_land_flag	1	int-16	None	Indicates whether the majority of AIRS footprints in the input data stream lies over land or over water. 0 = water 1 = land -1 = unknown
cnt_in	2	int-16	None	Total number of AIRS footprints in the input data stream that form the majority (i.e. match both the mean_day_flag and the mean_land_flag)
cnt_clear	2a	int-16	None	Count of input majority footprints representing clear FOV?s
cnt_hi_clouds	2b	int-16	None	Count of input majority footprints representing high clouds
cnt_cx2616_th_excl	2	int-16	None	Count of input footprints which pass the test (exclusively): cx2616 < th, where th is the applicable threshold value. Only this test is made. The other tests that normally must be passed to declare a footprint as “clear” are excluded.
cnt_cx2616_q2_th_excl	2	int-16	None	Count of input footprints which pass the tests (exclusively): cx2616 < th, q2 < th where th is the applicable threshold value
cnt_cx2616_tht1_excl	2	int-16	None	Count of input footprints which pass the test (exclusively): cx2616 < tht1, where tht1 is the applicable threshold value, tightened by

				one step
cnt_cx2616_q2_tht1_excl	2	int-16	None	Count of input footprints which pass the tests (exclusively): cx2616 < tht1, q2 < th where th is the applicable threshold value and tht1 is the threshold value, tightened by one step
cnt_cx2616_thr1_incl	2	int-16	None	Count of input footprints which would have passed all tests (inclusively), had the test: cx2616 < thr1, used a threshold value relaxed by one step
cnt_cx2616_q2_thr1_incl	2	int-16	None	Count of input footprints which would have passed all tests (inclusively), had the tests: cx2616 < tht1, q2 < th used a threshold value relaxed by one step
cnt_cx2616_thr2_incl	2	int-16	None	Count of input footprints which would have passed all tests (inclusively), had the test: cx2616 < thr1, used a threshold value relaxed by two steps
cnt_cx2616_q2_thr2_incl	2	int-16	None	Count of input footprints which would have passed all tests (inclusively), had the tests: cx2616 < tht1, q2 < th used a threshold value relaxed by two steps
sst1231_gfs_mean	2a	float-32	None	Difference between the surface skin temperature calculated using bt1231 and the predicted GFS SST - Mean
sst1231_gfs_stddev	2a	float-32	None	Difference between the surface skin temperature calculated using bt1231 and the predicted GFS SST - Standard Deviation
lp_mean	2a	float-32	None	Pseudo Lapse Rate - Mean
lp_stddev	2a	float-32	None	Pseudo Lapse Rate - Standard Deviation
q3_mean	2a	float-32	None	q3 - Mean where q3 is the difference between bt1231 and bt1227
q3_stddev	2a	float-32	None	q3 - Standard Deviation
bt1231_min	2	float-32	None	bt1231 - Minimum
bt1231_max	2	float-32	None	bt1231 - Maximum
bt1231_median	2	float-32	None	bt1231 - Median
lp_min	2	float-32	None	Pseudo Lapse Rate - Minimum
lp_max	2	float-32	None	Pseudo Lapse Rate - Maximum
lp_median	2	float32	None	Pseudo Lapse Rate - Median
d_sst1231_gfs_mean	2	float-32	None	abs(sst1231 - gfssst) - mean
cnt_d_sst1231_gfs_lt_2	2	int-16	None	Count of footprints having abs(sst1231 - gfssst) < 2 K
cnt_d_sst1231_gfs_gt_5	2	int-16	None	Count of footprints having abs(sst1231 - gfssst) > 5 K
cnt_d_sst1231_gfs_gt_10	2	int-16	None	Count of footprints having abs(sst1231 - gfssst) > 10 K
cnt_d_sst1231_gfs_gt_20	2	int-16	None	Count of footprints having abs(sst1231 - gfssst) > 20 K

cnt_d_sst1231_gfs_gt_30	2	int-16	None	Count of footprints having abs(sst1231 - gfssst) > 30 K
cnt_d_sst1231_gfs_gt_40	2	int-16	None	Count of footprints having abs(sst1231 - gfssst) > 40 K
cnt_d_sst1231_gfs_gt_50	2	int-16	None	Count of footprints having abs(sst1231 - gfssst) > 50 K
cnt_d_sst1231_gfs_gt_60	2	int-16	None	Count of footprints having abs(sst1231 - gfssst) > 60 K
cnt_d_sst1231_gfs_gt_70	2	int-16	None	Count of footprints having abs(sst1231 - gfssst) > 70 K
cnt_d_sst1231_gfs_gt_80	2	int-16	None	Count of footprints having abs(sst1231 - gfssst) > 80 K
cnt_d_sst1231_gfs_gt_90	2	int-16	None	Count of footprints having abs(sst1231 - gfssst) > 90 K
amsu_bt_mean	2	float-32	AMSU_Channel (15)	mean brightness temperature [K] for each AMSU-A channel
cnt_sun_glint	2	int-16	None	Count of footprints < 200 km distant from sun glint, which are valid (state = “process”) and have a maximum VIS Channel 3 radiance > 3000
CalChanSummary	1	uint-8	IR_Channel (2378)	Summary of calibration related occurrences for each IR channel in this granule, as detailed by the following flags: Bit 7 (MSB): scene over/underflow; Bit 6: (value 64) anomaly in offset calculation; Bit 5: (value 32) anomaly in gain calculation; Bit 4: (value 16) pop detected; Bit 3: (value 8) noise out of bounds; Bit 2: (value 4) anomaly in spectral calibration; Bit 1: (value 2) Telemetry; Bit 0: (LSB, value 1) unused (reserved); If all flags are zero the channel was well calibrated for all scanlines
NeN	1	float-32	IR_Channel (2378)	Noise-equivalent Radiances at 250K. Given in units of $mW/m^2/cm^{-1}$/ steradian

4. Options for Reading Data

There are many tools available in the public domain that will allow users to work easily with the HDF or HDFEOS data, either as command line utilities or GUI programs. In this section, only selected few are listed, not to be complete by any means. Please visit NCSA' HDF web site for a more comprehensive list: http://hdf.ncsa.uiuc.edu/tools.html.

4.1 Command-line utilities

4.1.1 read_hdf

The read_hdf tool is a command-line utility developed by GES DISC. It allows user to browse the file structure and display data values if desired. It is a menu-driven style of navigation.

Command line syntax:

```
read_hdf [-l] | [[-i | -d] [-a <output> | -b <base>.*.bin ]]  filename

Options/Arguments:

   [-i] -- run in interactive mode (default), or
   [-l] -- list a tree of file objects, or
   [-d] -- dump all HDF object types (no filtering)
   [-a <output>] -- ASCII output file name (default is <filename>.txt)
   [-b <base>] -- base binary output file name (default is <filename>)
                        creates two files per HDF object:
                        <base>.*.met for metadata, and <base>.*.bin
for binary data
                        (default output to stdout)
   filename -- name of the input HDF file
```

The source code is written in C language and can be obtained from GES DISC ftp server: ftp://disc1.gsfc.nasa.gov/software/aura/read_hdf/read_hdf.tar

4.1.2 ncdump

The ncdump tool can be used as a simple browser for HDF data files, to display the dimension names and sizes; variable names, types, and shapes; attribute names and values; and optionally, the values of data for all variables or selected variables in a netCDF file. The most common use of ncdump is with the –h option, in which only the header information is displayed.

```
ncdump [-c|-h] [-v ...] [[-b|-f] [c|f]] [-l len] [-n name] [-d n[,n]]
filename

Options/Arguments:

  [-c]                  Coordinate variable data and header information
  [-h]                  Header information only, no data
  [-v var1[,...]]       Data for variable(s) <var1>,... only
  [-b [c|f]]            Brief annotations for C or Fortran indices in
data
  [-f [c|f]]            Full annotations for C or Fortran indices in
data
  [-l len]              Line length maximum in data section (default
80)
  [-n name]       Name for netCDF (default derived from file name)
  [-d n[,n]]            Approximate floating-point values with less
precision
  filename        File name of input netCDF file
```

Note: the ncdump tool will only display variables whose ranks are great than 1. In other words, you will not see one dimensional vectors such as *satheight* using this tool. It can be very problematic especially for this product since many important fields are stored as vectors.

The ncdump program can be found in bin directory of the HDF installation area. Consult your local computer system administrator for the specifics.

4.1.3 hdp

The hdp utility is a HDF dumper developed by HDF group at NCSA.

```
Usage: hdp [-H] command [command options] <filelist>

         -H  Display usage information about the specified command.
             If no command is specified, -H lists all commands.

         Commands:
             list       lists contents of files in <filelist>
             dumpsds    displays data of SDSs in <filelist>
             dumpvd     displays data of vdatas in <filelist>.
             dumpvg     displays data of vgroups in <filelist>.
             dumprig    displays data of RIs in <filelist>.
             dumpgr     displays data of RIs in <filelist>.
```

For more information, please visit the NCSA web site: http://hdf.ncsa.uiuc.edu/hdp.html

4.2 GUI Tools

The HDFView is a visual tool for browsing and editing NCSA HDF4 and HDF5 files. Using HDFView, you can:

(1) view a file hierarchy in a tree structure
(2) create new file, add or delete groups and datasets
(3) view and modify the content of a dataset
(4) add, delete and modify attributes
(5) replace I/O and GUI components such as table view, image view and metadata view

More information can be found at the official HDFView web site. There is an add-on plug-in for handling HDFEOS data specifically.

4.3 Programming

AIRS science team provides reader software in IDL, MATLAB, C and FORTRAN programming language. You can download them from GES DISC web site:

(1) IDL / MATLAB suite along with sample HDFEOS data files
(2) FORTRAN / C suite along with sample HDFEOS data files

If you wish to program yourself, the HDFEOS programming model for accessing a swath data set through the swath (SW) interface is as follows:

(1) Open the file and obtain a file id from a file name.
(2) Open a swath data set by obtaining a swath id from a swath name.
(3) Perform desired operations on the data set.
(4) Close the swath data set by disposing of the swath id.
(5) Terminate swath access to the file by disposing of the file id.

A complete list of swath interface routines is summarized in the next two pages. To read an HDFEOS data file, access, basic I/O and inquiry routines are of particular interest.

Summary of HDF-EOS Swath Interface

Category	Routine Name		Description
	C	FORTRAN	
Access	SWopen	swopen	opens or creates HDF file in order to create, read, or write a swath
	SWcreate	swcreate	creates a swath within the file
	SWattach	swattach	attaches to an existing swath within the file
	SWdetach	swdetach	detaches from swath interface
	SWclose	swclose	closes file
Definition	SWdefdim	swdefdim	defines a new dimension within the swath
	SWdefdimmap	swdefmap	defines the mapping between the geolocation and data dimensions
	SWdefidxmap	swdefimap	defines a non-regular mapping between the geolocation and data dimension
	SWdefgeofield	swdefgfld	defines a new geolocation field within the swath
	SWdefdatafield	swdefdfld	defines a new data field within the swath
	SWdefprofile		defines the profile data structure within the swath
	SWdefcomp	swdefcomp	defines a field compression scheme
	SWwritegeometa	swwrgmeta	writes field metadata for an existing swath geolocation field
	SWwritedatameta	swwrdmeta	writes field metadata for an existing swath data field
Basic I/O	SWwritefield	swwrfld	writes data to a swath field
	SWreadfield	swrdfld	reads data from a swath field.
	SWwriteprofile		writes data to the profile
	SWreadprofile		reads data from the profile
	SWwriteattr	swwrattr	writes/updates attribute in a swath
	SWreadattr	swrdattr	reads attribute from a swath
	SWwritegrpattr	swwrgattr	writes/updates attribute as a swath
	SWreadgrpattr	swrdgattr	reads group attribute from a swath
	SWwritelocattr	swwrlattr	writes/updates local attribute in a swath
	SWreadlocattr	swrdlattr	reads local attribute from a swath
	SWsetfillvalue	swsetfill	sets fill value for the specified field
	SWgetfillvalue	swgetfill	retrieves fill value for the specified field
Inquiry	SWinqdims	swinqdims	retrieves information about dimensions defined in swath
	SWinqmaps	swinqmaps	retrieves information about the geolocation relations defined
	SWinqidxmaps	swinqimaps	retrieves information about the indexed geolocation/data mappings defined
	SWinqgeofields	swinqgflds	retrieves information about the geolocation fields defined
	SWinqdatafields	swinqdflds	retrieves information about the data fields defined
	SWinqattrs	swinqattrs	retrieves number and names of attributes defined
	SWinqgrpattrs	swinqgattrs	retrieves number and names of group attributes defined
	SWinqlocattrs	swinqlattrs	retrieves number and names of local attributes defined
	SWnentries	swnentries	returns number of entries and descriptive string buffer size for a specified entity
	SWdiminfo	swdiminfo	retrieve size of specified dimension
	SWgrpattrinfo	swgattrinfo	retrieves information about swath group attributes
	SWlocattrinfo	swlattrinfo	returns information about swath local attributes

Summary of HDF-EOS Swath Interface

Category	Routine Name		Description
	C	FORTRAN	
	SWmapinfo	swmapinfo	retrieve offset and increment of specified geolocation mapping
	SWidxmapinfo	swimapinfo	retrieve offset and increment of specified geolocation mapping
	SWattrinfo	swattrinfo	returns information about swath attributes
	SWfieldinfo	swfldinfo	retrieve information about a specific geolocation or data field
	SWcompinfo	swcompinfo	retrieve compression information about a field
	SWinqswath	swinqswath	retrieves number and names of swaths in file
	SWregionindex	swregidx	returns information about the swath region ID
	SWupdateidxmap	swupimap	update map index for a specified region
Subset	SWgeomapinfo	swgmapinfo	retrieves type of dimension mapping when first dimension is geodim
	SWdefboxregion	swdefboxreg	define region of interest by latitude/longitude
	SWregioninfo	swreginfo	returns information about defined region
	SWextractregion	swextreg	read a region of interest from a field
	SWdeftimeperiod	swdeftmeper	define a time period of interest
	SWperiodinfo	swperinfo	retuns information about a defined time period
	SWextractperiod	swextper	extract a defined time period
	SWdefvrtregion	swdefvrtreg	define a region of interest by vertical field
	SWdupregion	swdupreg	duplicate a region or time period
	SWdefscanregion		define region of interest based on range of scans

5. Data Services

5.1 AIRS File Subsetting Service

Users can limit number of files for download by specifying appropriate spatial and temporal constraints in search engines like Mirador (http://mirador.gsfc.nasa.gov). The total download size can be further reduced by choosing a subset of variables, channels within each file through the subsetting service. AIRS file subsetting service is provided as a part of the data ordering process through the Mirador search engine. The table below shows the available subsetting options for AIRS Level-1B and Level-2 products.

Product Name	Variable	Channel	Spatial
AIRIBRAD		√	
AIRABRAD		√	
AIRVBRAD		√	
AIRXBCAL	√	√	√
AIRX2RET / AIRH2RET	√		
AIRI2CCF		√	
AIRX2SUP / AIRH2SUP	√		

6. Data Interpretation and Screen

6.1 Geolocation Coordinates

Latitude[GeoTrack] and Longitude[GeoTrack] are the geodetic coordinates for the footprint. The valid ranges are [-180°, 180°] for longitudes and [-90°, 90°] for latitudes.

Time[GeoTrack] (TAI time). TAI, Temps Atomique International (French for International Atomic Time), measures real time. One second of TAI time is a constant duration defined by cesium radiation. The AIRS TAI time is the number of seconds elapsed since January 1, 1993. Need a TAI to UTC time conversion routine to convert TAI seconds to UTC time. Alternatively, the start time of a granule (start_year, start_month, start_day, start_hour, start_minute, start_sec) can be read directly from file attributes.

6.2 Data Screening

The *reason* parameter details the reason why a particular footprint is included in the file.

1 = Clear (cloud-free) location
2 = Calibration site identified by field “site”.
4 = High clouds
8 = Randomly selected location

Note: Footprints may be selected for more than one reason. In that case the reason codes are combined (bitwise or’d).

If you want to select observations within 30 miles of a particular ground calibration site, you can filter the data by the *site* code:

0 = footprint selection reason is not “calibration site”
1 = Egypt 1 Lat: 27.12°N, Lon: 026.10°E
2 = Simpson Desert Lat: 24.50°S, Lon: 137.00°E
3 = Dome Concordia Start Lat: 75.10°S, Lon: 123.40°E
4 = Mitu, Columbia Lat: 01.50°N, Lon: 069.50°W
5 = Boumba, Cameroon Lat: 03.50°N, Lon: 014.50°E
6 = Railroad Valley, NV Lat: 38.50°N, Lon: 115.70°W
7 = SPG/Arm-Cart, OK Lat: 36.60°N, Lon: 97.50°W
8 = Manus, Bismarck Archipelago Lat: 02.00°S, Lon: 147.40°E

9 = Nauru, Micronesia Lat: 00.50°S, Lon: 166.60°E
10 = North Pole Lat: 90.00°N, Lon: N/A
11 = South Pole Lat: 90.00°S, Lon: N/A
12 = Surgut, Siberian tundra Lat: 61.15°N Lon: 73.37°E
13 = Yunnan rain forest Lat: 23.90°N Lon:100.50°E
14 = Barrow, Alaska Lat: 71.32°N Lon:156.66°W
15 = Atqusuk, Alaska Lat: 70.32°N Lon:156.67°W
16 = Darwin, Australia Lat: 12.42°S Lon:130.89°E
17 = Lake Qinghai, China Lat: 36.75?N Lon:100.33?E
18 = Dunhuang, Gobi desert Lat: 40.17°N Lon: 94.33°E
19 = Lake Titicaca Lat: 15.88°S Lon: 69.33°W
20 = Lake Tahoe, CA Lat: 39.10°N Lon: 120.04°W

7. More Information

Web resources for AIRS data users:

NASA/JPL:

- AIRS Project Web Site: http://airs.jpl.nasa.gov/
- Ask AIRS Science Questions: http://airs.jpl.nasa.gov/AskAirs/

NASA/GSFC:

- AIRS Data Support Main Page: http://disc.sci.gsfc.nasa.gov/AIRS/
- AIRS Data Access: http://disc.sci.gsfc.nasa.gov/AIRS/data_access.shtml
- AIRS Documentation: http://disc.sci.gsfc.nasa.gov/AIRS/documentation.shtml
- AIRS Products: http://disc.sci.gsfc.nasa.gov/AIRS/data_products.shtml

For further assistance, please use this contact information:

Email: help-disc@listserv.gsfc.nasa.gov
Voice: 301-614-5224
Fax: 301-614-5268

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