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README Document for

AIRS Level-2 Version 005 Standard Products

AIRX2RET / AIRH2RET / AIRS2RET

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Last revised, February 4, 2008

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September 5, 2007

Revision History

Revision Date	***Changes***	***Author***
8/23/2007	Initial version	Jason Li
9/7/2007	Revised based on review	Jason Li
2/4/2008	Revised to include AIRH2RET and AIRS2RET	Jason Li
7/21/2009	Removed reference to retired WHOM search engine	Randy Barth

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Introduction

This document applies to the Atmospheric Infrared Sounder (AIRS) Standard Product family: AIRX2RET, AIRH2RET and AIRS2RET. The AIRS Standard Products consist of retrieved estimates of cloud and surface properties, outgoing longwave radiation, profiles of temperature and water vapor, and total column amount of atmospheric minor gases such as ozone, CH4 and CO. They are the results of employing the combined AIRS-IR/AMSU-Microwave retrieval stages of the AIRS algorithm. Quality flags and error estimates associated with these quantities are also part of the Standard Product. Generally speaking, temperature profiles have an accuracy of 1 K per 1 km thick layer in the troposphere and moisture profiles have an accuracy of 20% per 2 km thick layer in the lower troposphere (20%-60% in the upper troposphere).

The Standard Products also contain a set of Microwave-Only (MW-Only) retrieval parameters that are retrieved by the MW retrieval stage of the AIRS algorithm. No IR data are used to retrieve these parameters. Note however, MW-Only retrieval parameters have very different characteristics from their counterparts obtained by the combined AIRS-IR and AMSU-MW retrieval algorithm. Therefore, it is best to avoid mixing between the two sets in data analysis.

From 705.3 km altitude, an Advanced Microwave Sounding Unit (AMSU-A) footprint at nadir is about 45 km in diameter. It contains 3×3 AIRS IR observations (each is about 13.5 km) as depicted in Figure 1. Retrievals are performed inside AMSU-A footprints. Therefore, the final retrieval results have a horizontal resolution of 45 km. Along the vertical direction, the temperature profiles are reported at 28 pressure levels between 1100 mb and 0.1 mb. The moisture profiles are layered quantities, and there are total of 14 layers between 1100 mb and 50 mb.

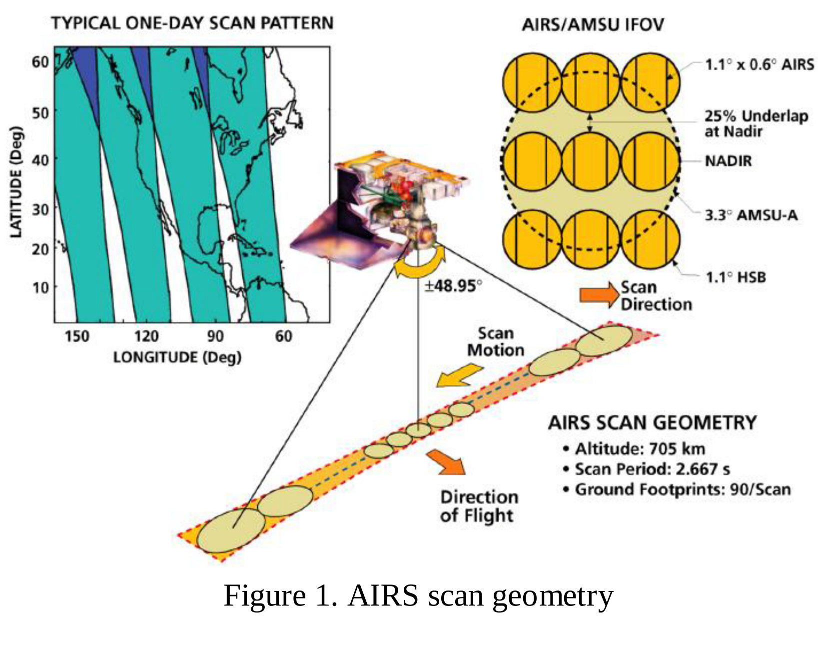

Figure 1. AIRS scan geometry

Currently, there are three flavors of AIRS Level-2 standard products depending on instrument combination used in the retrieval process as summarized in Table 1:

Table 1. Three Flavors of the AIRS Level-2 Standard Products

Products	Description	Notes
AIRX2RET	Level-2 retrieval product crated using AIRS IR, AMSU without-HSB	Has been the Level-2 flagship product. It covers from the beginning of the mission to the present.
AIRH2RET	Level-2 retrieval product created using AIRS IR, AMSU and HSB	Best quality retrievals among three flavors of the standard products. However, the HSB instrument failed on 2003-FEB-05. It is when this data collection ends.
AIRS2RET	Level-2 retrieval product created using AIRS IR only	Part of the contingency plan in case the AMSU instrument fails.

AIRS science team continues to improve the retrieval 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 5.0.14.0 (or simply referred to as Version 5) data is available to the public and the first product file for AIRS Level-2 Standard Product starts on 2002-08-30 22:29:26 UTC.

1.1 AIRS Instrument Description

1.1.1 Atmospheric Infrared Sounder (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 2.

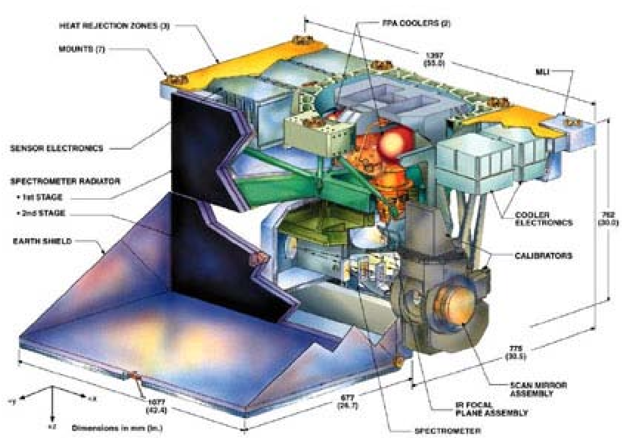

Figure 2. AIRS instrument cutaway drawing.

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 2. Technology - 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 Advanced Microwave Sounding Unit (AMSU-A)

AMSU-A (as seen in Figure 3) 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.

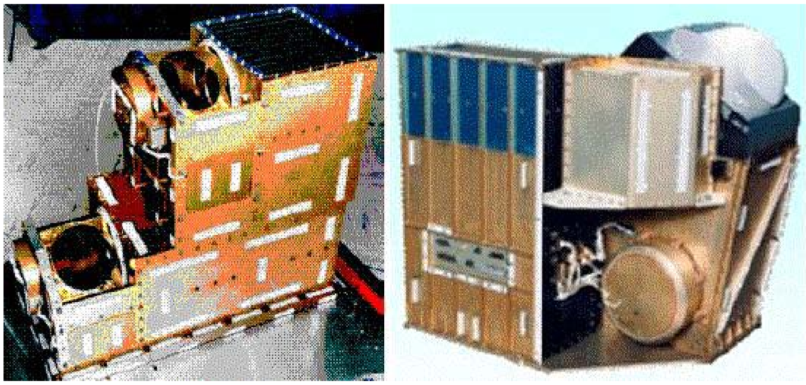

Figure 3. View of AMSU-A1 (left) and AMSU-A2 right.

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

1.1.3 Humidity Sounder - Brazil (HSB)

The Humidity Sounder for Brazil (HSB) was a four-channel passive microwave radiometer, providing supplementary water vapor and liquid data to be used in the cloud clearing process. HSB was manufactured by Matra Marconi Space, Limited (MMS), in the United Kingdom under a contract with the Brazilian National Institute for Space Research, INPE. The scan mirror motor failed on February 5, 2003. Thus, all data processed with HSB information ends on that day.

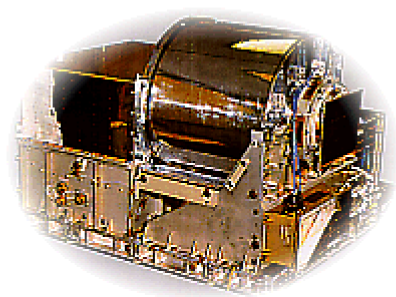

Figure 4. HSB instrument. (http://www.inpe.br/programas/hsb/ingl/index.html)

The HSB is 4 moist sounding channel version of AMSU-B, designed to detect radiances in the range of 150 to 183.31 GHz. One window channel (at 150 GHz) measures a part of the water vapor continuum, while three are grouped around the 183-GHz water vapor absorption line. Like AMSU-B, it samples ninety 1.1 ° scenes per 2.67-second cross track scan. Due to the higher spatial resolution (which equals that of AIRS IR) and a higher scan rate, the measurement density is 2.4 times that of AMSU-A (20 % less than for AMSU-B). HSB is very similar to AMSU-A, except that is contains only one antenna/receiver system. It was a part of a sounding system that acts in a synergic way, and provided humidity and profile much more accurately than that of sounders currently in the market. It also had the capacity of detecting precipitation under the clouds. Instrument and channel characteristics are summarized in table 4.

Table 4 (a). HSB Instrument Characteristics

Weight	60 kg
Dimensions	526 mm x 700 mm x 650 mm
Power	80W
Swath	1650 km
Spatial resolution	13.5 km at nadir
Field of View	1.1º
Data Rate	4.2 Kbps
Temperature Sensitivity	1.0 K to 1.2 K
Scan: angle	± 48.95º period: 8/3 s

Table 4 (b). HSB Channel Characteristics

Channel No.	Center Freq (GHz)	Bandwidth (GHz)	Function	NEDT (K)
1*				N/A
2	150.0	4000	Water Vapor	0.68
3	183.31 ± 1.0	2x500	Water Vapor	0.57
4	183.31 ± 3.0	2x1000	Water Vapor	0.39
5	183.31 ± 7.0	2x2000	Water Vapor	0.30

* Channel 1 (89 GHz) has been deleted for the HSB

1.2 Background on Algorithm

Please refer to the Advanced Theoretical Basis Document (ATBD) for AIRS Level-2 products, AIRS-TEAM RETRIEVAL FOR CORE PRODUCTS AND GEOPHYSICAL PARAMETERS. Here is the table of contents:

The retrieval flow is also summarized in the AIRS/AMSU/HSB Version 5 Retrieval Flow document. Here is the table of contents of that document:

1.3 Data Disclaimer

AIRS science team provides AIRS/AMSU/HSB Version 5 Data Disclaimer document as a part of Version 005 data release, here is the table of contents:

2. Data Organization

2.1 Granularity

The continuous AIRS data is broken into a series of 6-minute segments. Each segment is a file. Each file contains all observations of a given type made during a period of exactly 6 minutes. For each day there are 240 files (as known as granules), numbered 1-240. Over the course of 6 minutes the EOS-Aqua platform travels approximately 1500 km, and the AIRS-suite instruments scan (whisk broom) a swath approximately 1500 km wide.

Start times of granules are keyed to the start of 1958. Because of leap seconds, they do not start at the same time as days do. For data from launch through December-31-2005, granule 1 spans 00:05:26 UTC - 00:11:26 UTC and granule 240 starts at 23:59:26 UTC and ends at 00:05:26 UTC the next day. For data December-31-2005 through the next leap second, granule 1 spans 00:05:25 UTC - 00:11:25 UTC and granule 240 starts at 23:59:25 UTC and ends at 00:05:25 UTC the next day.

2.2 Filenaming Convention

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

AIRS.*yyyy***.***mm***.***dd***.***ggg***.L2.***productType***.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]
- ggg = granule number [1-240]
- productType: can be one of RetStd, RetStd_H, RetStd_IR.
- 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.2004.01.01.240.L2.RetStd.v5.0.14.0.G07193010935.hdf

2.3 File Format and Structure

AIRS Level-2 standard 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-2 Standard 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].

Each AIRS Level-2 Standard Product file contains a swath whose swath name is "L2_Standard_atmospheric&surface_product". This swath is made up of four major groups: dimensions, geolocation fields, attributes and data fields:

Dimensions: These are HDF-EOS swath dimensions. The names "GeoTrack" and "GeoXTrack" have a special meaning for this document: "GeoTrack" is understood to be the dimension along the path of the spacecraft, and "GeoXTrack" is the dimension across the spacecraft track, starting on the left looking forward along the spacecraft track. There may also be a second across-track dimension "CalXTrack," equivalent to "GeoXTrack," except that "CalXTrack" refers to the number of calibration footprints per scanline. "GeoTrack" is 45 for large-spot products (AMSU-A, Level-2, cloud-cleared AIRS) and 135 for small-spot products (AIRS, Vis/NIR, HSB).

Geolocation fields: These are all 64-bit floating-point fields that define the location of the data in space and time. They appear for every footprint (GeoTrack * GeoXTrack times) and correspond to footprint center coordinates and shutter time.

Data Fields: Depending on the frequency of appearances in the file, data fields can be subdivided into three categories, per-granule, along-track and full swath data fields. *Per-granule data fields* appear only once per granule. *Along-track data fields* are fields that occur once for every scanline. *The full swath data fields* appear on every footprint of every scanline in the granule (GeoTrack * GeoXTrack times).

Swath Attributes: These are scalar or string fields that appear only once per granule. They are attributes in the HDF-EOS Swath sense.

The HDFEOS programming interface provides information query function calls on all three groups. The content inside each group is detailed in the data content section.

[1] See section 4.3 for more details.

2.4 Key Science Data Fields

The key data fields are the ones most likely to be use by users. For an in-depth discussion on associated quality indicators, caveats and reference papers, please consult the Level-2 Standard Product QuickStart Guide document.

Many science parameters come with companion error estimates for them. Typically, their names are constructed by appending the "Err" or "_err" tag to the science parameter name. For example, TSurfAirErr is the error estimate for the TsurfAir. In another example, CH4_VMR_eff_err is the error estimate for CH4_VMR_eff. The data contents section describes all the parameters contained within an AIRS Level-2 Standard Product file.

2.4.1 AIRS Standard Temperature Fields

Field Name	Dimension per FOV	Description
TairStd	numTempLayers=28	Retrieved Atmospheric Temperature Profile (K)
TSurfAir	1	Retrieved Surface Air Temperature (K)
PTropopause	1	Pressure at tropopause (mb)
T_Tropopause	1	Temperature at tropopause (K)
GP_Tropopause	1	Geopotential height (above mean sea level) at tropopause (m)
GP_Height	StdPressureLev=28	Geopotential height (above mean sea level) for each pressStd (m)

2.4.2 AIRS Standard Moisture Fields

Field Name	Dimension per FOV	Description
H2OMMRStd	H2OPressureLay=14	Retrieved Water Vapor Mass Mixing Ratio Profile, (gm/kg)
H2OMMRSat	H2OPressureLay=14	Saturation Water Vapor Mass Mixing Ratio Profile over equilibrium phase, (gm/kg)
H2OMMRSat_liquid	H2OPressureLay=14	Saturation Water Vapor Mass Mixing Ratio Profile over liquid phase, (gm/kg)
totH2OStd	1	Retrieved Total Precipitable Water Vapor, (kg/m2)
H2O_verticality	H2OFunc=11	Sum of the rows of H2O_ave_kern, (unitless)

2.4.3 AIRS Standard Surface Fields

Field Name	Dimension per FOV	Description
PSurfStd	1	Surface pressure, interpolated from the NCEP GFS forecasts and local DEM topography, (mb)
TSurfStd	1	Surface skin temperature, (K)
TSurfAir	1	Retrieved Surface Air Temperature (K)
emisIRStd	HingeSurf(=100)	Spectral IR surface emissivities in order of increasing frequency from 649 to 2666 cm-1 by a series of ?hinge points? that differ between land and ocean. Only the first numHingeSurf elements are valid. (unitless)

2.4.4 AIRS Standard Cloud Fields and OLR

Field Name	Dimension per FOV	Description
CldFrcStd	3x3x2	Effective cloud fraction in each of 9 AIRS spots associated with the AMSU FOV, in order of increasing pressure.Only first numCloud (3x3) values are valid, (unitless)
PCldTopStd	2	Cloud top pressures for each valid cloud layer, (mb)
TCldTopStd	2	Cloud top temperatures for each valid cloud layer, (K)
olr	1	Outgoing LW radiation flux integrated over 2 to 2800 cm-1, (W/m2)
clrolr	1	Clear sky outgoing longwave radiation flux integrated over 2 to 2800 cm-1, (W/m2)

2.4.5 AIRS Standard Minor Gases Fields

2.4.5.1 AIRS Standard Ozone Product

Field Name	Dimension per FOV	Description
O3VMRStd	StdPressureLay=28	Retrieved Ozone Volume Mixing Ratio Profile (vmr), (unitless)
TotO3Std	1	Retrieved Total Ozone Burden, (DU)
O3_verticality	O3Func=9	Sum of rows of O3_ave_kern (unitless)
O3_dof	1	Degrees of freedom, measure of amount of information in O3 retrieval, (unitless)

2.4.5.2 AIRS Standard Carbon Monoxide Fields

Field Name	Dimension per FOV	Description
CO_eff_press	COFunc=9	CO effective pressure for the center of each trapezoid. These CO trapezoids were chosen to approximately match MOPITT standard levels, (mb)
CO_VMR_eff	COFunc=9	Effective CO Volume Mixing Ratio Profile (vmr) for each trapezoid, (unitless)
CO_total_column	1	Retrieved total column CO, (molecules/cm2)
CO_verticality	COFunc=9	Sum of rows of CO_ave_kern, (unitless)
CO_dof	1	Degrees of freedom, measure of amount of information in CO retrieval, (unitless)

2.4.5.3 AIRS Standard Methane Fields

Field Name	Dimension per FOV	Description
CH4_eff_press	CH4Func=7	CH4 effective pressure for the center of each trapezoid, (mb)
CH4_VMR_eff	CH4Func=7	Effective CH4 Volume Mixing Ratio Profile (vmr) for each trapezoid, (unitless)
CH4_total_column	1	Retrieved total column CH4, (molecules/cm2)
CH4_verticality	CH4Func=7	Sum of rows of O3_ave_kern, (unitless)
CH4_dof	1	Degrees of freedom, measure of amount of information in CH4 retrieval, (unitless)

2.4.5.4 AIRS Standard Sulfur Dioxide and Dust Fields

Field Name	Dimension per FOV	Description
NumSO2FOVs	1	Number of FOVs (out of a nominal 1350) in granule with a significant SO2 content based on the value of BT_diff_SO2, located in the L2 Support Product, (unitless)
Dust_flag	3x3	Flag indicating whether dust has been detected in each AIRS spot within an AMSU FOV. Set to 1 if dust has been detected; set to to 0 if dust has not been detected, (unitless)

3. Data Contents

3.1 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 hidden dimension of "GeoTrack"; "Full Swath" data fields have hidden dimensions of both "GeoTrack" and "GeoXTrack".

NAME	VALUE	EXPLANATION
GeoXTrack	30	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)
StdPressureLev	28	Number of standard pressure altitude levels (from bottom of the atmosphere up); nSurfStd is the 1-based index of the first valid level for a given profile. Any levels before this are below the surface. Since the actual surface will not be be exactly at this level, it will be necessary to extrapolate or interpolate to get precise surface values. See entries for specific fields for more details.
StdPressureLay	28	Number of standard pressure altitude layers (Always equal to StdPressureLev: last layer goes to the top of the atmosphere); nSurfStd is the 1-based index of the first valid layer for a given profile. Any layers before this are below the surface. Since the actual surface will not be be exactly at the bottom of this layer, it will be necessary to extrapolate or interpolate to get total amounts for surface layers. See entries for specific fields for more details.
AIRSXTrack	3	The number of AIRS cross-track spots per AMSU-A spot. Direction is the same as GeoXTrack -- starting at the left and increasing towards the right as you look along the satellite's path
AIRSTrack	3	The number of AIRS along-track spots per AMSU-A spot. Direction is the same as GeoTrack -- parallel to the satellite's path, increasing with time
Cloud	2	Cloud layer dimension in order of increasing pressure. Only first numCloud elements are valid
ChanAMSUA	15	Dimension of AMSU-A Channel array (Channel 1: 23.8 GHz; Ch 2: 31.4 GHz; Ch 3: 50.3 GHz; Ch 4: 52.8 GHz; Ch 5: 53.596 +/- 0.115 GHz; Ch 6: 54.4 GHz; Ch 7: 54.94 GHz; Ch 8: 55.5 GHz; Ch 9: f0; Ch 10: f0 +/- 0.217 GHz Ch 11: f0 +/- df +/- 48 MHz; Ch 12: f0 +/- df +/- 22 MHz; Ch 13: f0 +/- df +/- 10 MHz; Ch 14: f0 +/- df +/- 4.5 MHz; Ch 15: 89 GHz (f0 = 57290.344 MHz; df = 322.4 MHz))
ChanHSB	5	Dimension of HSB Channel array (Channel 1: Deleted 89.0 GHz channel: always invalid; Ch 2: 150.0 GHz; Ch 3: f0 +/- 1.0 GHz; Ch 4: f0 +/- 3.0 GHz; Ch 5: f0 +/- 7.0 GHz (f0 = 183.31 GHz))
MWHingeSurf	7	Number of standard frequency hinge points in Microwave surface emissivity and surface brightness. Frequencies are 23.8, 31.4, 50.3, 52.8, 89.0, 150.0, 183.31 GHz respectively.Values are also found in field MWHingeSurfFreqGHz.
H2OFunc	11	Functions on which water vapor retrieval is calculated

3.2 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

3.3 Swath Attributes

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

NAME	TYPE	EXPLANATION
NumSO2FOVs	16-bit unsigned integer	Number of fields-of-view (out of a nominal 1350) with a signifcant SO2 concentration based on the value of BT_diff_SO2.
processing_level	string of 8-bit characters	Zero-terminated character string denoting processing level ("Level2")
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
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
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 (1 * num_scansets)
start_Latitude	64-bit floating-point	Geodetic Latitude of spacecraft at start of granule (subsatellite 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 (subsatellite 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 (subsatellite 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 (subsatellite 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)
orbitgeoqa	32-bit unsigned integer	Orbit Geolocation QA:; Bit 0: (LSB, value 1) bad input value (last scanline); Bit 1: (value 2) bad input value (first scanline); Bit 2: (value 4) PGS_EPH_GetEphMet() gave PGSEPH_E_NO_SC_EPHEM_FILE; Bit 3: (value 8) PGS_EPH_GetEphMet() gave PGSEPH_E_BAD_ARRAY_SIZE; Bit 4: (value 16) PGS_EPH_GetEphMet() gave PGSTD_E_TIME_FMT_ERROR; Bit 5: (value 32) PGS_EPH_GetEphMet() gave PGSTD_E_TIME_VALUE_ERROR; Bit 6: (value 64) PGS_EPH_GetEphMet() gave PGSTD_E_SC_TAG_UNKNOWN; Bit 7: (value 128) PGS_EPH_GetEphMet() gave PGS_E_TOOLKIT; Bit 8: (value 256) PGS_TD_UTCtoTAI() gave PGSTD_E_NO_LEAP_SECS; Bit 9: (value 512) PGS_TD_UTCtoTAI() gave PGSTD_E_TIME_FMT_ERROR; Bit 10: (value 1024) PGS_TD_UTCtoTAI() gave PGSTD_E_TIME_VALUE_ERROR; Bit 11: (value 2048) PGS_TD_UTCtoTAI() gave PGS_E_TOOLKIT;

		Bit 12: (value 4096) PGS_CSC_DayNight() gave PGSTD_E_NO_LEAP_SECS; Bit 13: (value 8192) PGS_CSC_DayNight() gave PGSCSC_E_INVALID_LIMITTAG; Bit 14: (value 16384) PGS_CSC_DayNight() gave PGSCSC_E_BAD_ARRAY_SIZE; Bit 15: (value 32768) PGS_CSC_DayNight() gave PGSCSC_W_ERROR_IN_DAYNIGHT; Bit 16: (value 65536) PGS_CSC_DayNight() gave PGSCSC_W_BAD_TRANSFORM_VALUE; Bit 17: (value 131072) PGS_CSC_DayNight() gave PGSCSC_W_BELOW_HORIZON; Bit 18: (value 262144) PGS_CSC_DayNight() gave PGSCSC_W_PREDICTED_UT1 (This is expected except when reprocessing.); Bit 19: (value 524288) PGS_CSC_DayNight() gave PGSTD_E_NO_UT1_VALUE; Bit 20: (value 1048576) PGS_CSC_DayNight() gave PGSTD_E_BAD_INITIAL_TIME; Bit 21: (value 2097152) PGS_CSC_DayNight() gave PGSCBP_E_TIME_OUT_OF_RANGE; Bit 22: (value 4194304) PGS_CSC_DayNight() gave PGSCBP_E_UNABLE_TO_OPEN_FILE; Bit 23: (value 8388608) PGS_CSC_DayNight() gave PGSMEM_E_NO_MEMORY; Bit 24: (value 16777216) PGS_CSC_DayNight() gave PGS_E_TOOLKIT; Bit 25-31: not used
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
num_fpe	16-bit integer	Number of floating point errors
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)
CO_first_guess	string of 8-bit characters	Name of CO First Guess source.
CH4_first_guess	string of 8-bit characters	Name of CH4 First Guess source.

3.4 Per-Granule Data Fields

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

NAME	TYPE	EXTRA DIMENSIONS	EXPLANATION
pressStd	32-bit floating-point	StdPressureLev (= 28)	Standard pressures in mbar (bottom of the atmosphere first)
pressH2O	32-bit floating-point	H2OPressureLev (= 15)	Water vapor pressures in mbar (bottom of the atmosphere first)
CO_trapezoid_layers	32-bit integer	COFunc (= 9)	Layers on which the CO variables are defined.
CH4_trapezoid_layers	32-bit integer	CH4Func (= 7)	Layers on which the CH4 variables are defined.

3.5 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.)
satgeoqa	32-bit unsigned integer	None	Satellite Geolocation QA flags: Bit 0: (LSB, value 1) bad input value; Bit 1: (value 2) PGS_TD_TAItoUTC() gave PGSTD_E_NO_LEAP_SECS; Bit 2: (value 4) PGS_TD_TAItoUTC() gave PGS_E_TOOLKIT; Bit 3: (value 8) PGS_EPH_EphemAttit() gave PGSEPH_W_BAD_EPHEM_VALUE; Bit 4: (value 16) PGS_EPH_EphemAttit() gave PGSEPH_E_BAD_EPHEM_FILE_HDR; Bit 5: (value 32) PGS_EPH_EphemAttit() gave PGSEPH_E_NO_SC_EPHEM_FILE; Bit 6: (value 64) PGS_EPH_EphemAttit() gave PGSEPH_E_NO_DATA_REQUESTED; Bit 7: (value 128) PGS_EPH_EphemAttit() gave PGSTD_E_SC_TAG_UNKNOWN; Bit 8: (value 256) PGS_EPH_EphemAttit() gave PGSEPH_E_BAD_ARRAY_SIZE; Bit 9: (value 512) PGS_EPH_EphemAttit() gave PGSTD_E_TIME_FMT_ERROR; Bit 10: (value 1024) PGS_EPH_EphemAttit() gave PGSTD_E_TIME_VALUE_ERROR; Bit 11: (value 2048) PGS_EPH_EphemAttit() gave PGSTD_E_NO_LEAP_SECS; Bit 12: (value 4096) PGS_EPH_EphemAttit() gave PGS_E_TOOLKIT; Bit 13: (value 8192) PGS_CSC_ECItoECR() gave PGSCSC_W_BAD_TRANSFORM_VALUE; Bit 14: (value 16384) PGS_CSC_ECItoECR() gave PGSCSC_E_BAD_ARRAY_SIZE; Bit 15: (value 32768) PGS_CSC_ECItoECR() gave PGSTD_E_NO_LEAP_SECS; Bit 16: (value 65536) PGS_CSC_ECItoECR() gave PGSTD_E_TIME_FMT_ERROR; Bit 17: (value 131072) PGS_CSC_ECItoECR() gave PGSTD_E_TIME_VALUE_ERROR; Bit 18: unused (set to zero); Bit 19: (value 524288) PGS_CSC_ECItoECR() gave PGSTD_E_NO_UT1_VALUE; Bit 20: (value 1048576) PGS_CSC_ECItoECR() gave PGS_E_TOOLKIT; Bit 21: (value 2097152) PGS_CSC_ECRtoGEO() gave PGSCSC_W_TOO_MANY_ITERS; Bit 22: (value 4194304) PGS_CSC_ECRtoGEO() gave PGSCSC_W_INVALID_ALTITUDE; Bit 23: (value 8388608) PGS_CSC_ECRtoGEO() gave PGSCSC_W_SPHERE_BODY; Bit 24: (value 16777216) PGS_CSC_ECRtoGEO() gave PGSCSC_W_LARGE_FLATTENING; Bit 25: (value 33554432) PGS_CSC_ECRtoGEO() gave PGSCSC_W_DEFAULT_EARTH_MODEL; Bit 26: (value 67108864) PGS_CSC_ECRtoGEO() gave PGSCSC_E_BAD_EARTH_MODEL;

			Bit 27: (value 134217728) PGS_CSC_ECRtoGEO() gave PGS_E_TOOLKIT; Bit 28-31: not used
glintgeoqa	16-bit unsigned integer	None	Glint Geolocation QA flags: Bit 0: (LSB, value 1) bad input value; Bit 1: (value 2) glint location in Earth's shadow (Normal for night FOVs); Bit 2: (value 4) glint calculation not converging; Bit 3: (value 8) glint location sun vs. satellite zenith mismatch; Bit 4: (value 16) glint location sun vs. satellite azimuth mismatch; Bit 5: (value 32) bad glint location; Bit 6: (value 64) PGS_CSC_ZenithAzimuth() gave any 'W' class return code; Bit 7: (value 128) PGS_CSC_ZenithAzimuth() gave any 'E' class return code; Bit 8: (value 256) PGS_CBP_Earth_CB_Vector() gave any 'W' class return code; Bit 9: (value 512) PGS_CBP_Earth_CB_Vector() gave any 'E' class return code; Bit 10: (value 1024) PGS_CSC_ECItoECR() gave any 'W' class return code except PGSCSC_W_PREDICTED_UT1 (for Glint); Bit 11: (value 2048) PGS_CSC_ECItoECR() gave any 'E' class return code (for Glint); Bit 12: (value 4096) PGS_CSC_ECRtoGEO() gave any 'W' class return code (for Glint); Bit 13: (value 8192) PGS_CSC_ECRtoGEO() gave any 'E' class return code (for Glint); Bit 14: (value 16384) PGS_CSC_ECItoECR() gave any 'W' class return code except PGSCSC_W_PREDICTED_UT1 ; Bit 15: (value 32768) PGS_CSC_ECItoECR() gave any 'E' class return code
moongeoqa	16-bit unsigned integer	None	Moon Geolocation QA flags: Bit 0: (LSB, value 1) bad input value; Bit 1: (value 2) PGS_TD_TAItoUTC() gave PGSTD_E_NO_LEAP_SECS; Bit 2: (value 4) PGS_TD_TAItoUTC() gave PGS_E_TOOLKIT; Bit 3: (value 8) PGS_CBP_Sat_CB_Vector() gave PGSCSC_W_BELOW_SURFACE; Bit 4: (value 16) PGS_CBP_Sat_CB_Vector() gave PGSCBP_W_BAD_CB_VECTOR; Bit 5: (value 32) PGS_CBP_Sat_CB_Vector() gave PGSCBP_E_BAD_ARRAY_SIZE; Bit 6: (value 64) PGS_CBP_Sat_CB_Vector() gave PGSCBP_E_INVALID_CB_ID; Bit 7: (value 128) PGS_CBP_Sat_CB_Vector() gave PGSMEM_E_NO_MEMORY; Bit 8: (value 256) PGS_CBP_Sat_CB_Vector() gave PGSCBP_E_UNABLE_TO_OPEN_FILE; Bit 9: (value 512) PGS_CBP_Sat_CB_Vector() gave PGSTD_E_BAD_INITIAL_TIME; Bit 10: (value 1024) PGS_CBP_Sat_CB_Vector() gave PGSCBP_E_TIME_OUT_OF_RANGE; Bit 11: (value 2048) PGS_CBP_Sat_CB_Vector() gave PGSTD_E_SC_TAG_UNKNOWN; Bit 12: (value 4096) PGS_CBP_Sat_CB_Vector() gave PGSEPH_E_BAD_EPHEM_FILE_HDR; Bit 13: (value 8192) PGS_CBP_Sat_CB_Vector() gave PGSEPH_E_NO_SC_EPHEM_FILE; Bit 14: (value 16384) PGS_CBP_Sat_CB_Vector() gave PGS_E_TOOLKIT; Bit 15: not used
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)
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.
glintlat	32-bit floating-	None	Solar glint geodetic latitude in degrees North at nadirTAI (-90.0 ... 90.0)

	point		
glintlon	32-bit floating-point	None	Solar glint geodetic longitude in degrees East at nadirTAI (-180.0 ... 180.0)

3.6 Full Swath Data Fields

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

NAME	TYPE	EXTRA DIMENSIONS	EXPLANATION
ftptgeoqa	32-bit unsigned integer	None	Footprint Geolocation QA flags: Bit 0: (LSB, value 1) bad input value; Bit 1: (value 2) PGS_TD_TAItoUTC() gave PGSTD_E_NO_LEAP_SECS; Bit 2: (value 4) PGS_TD_TAItoUTC() gave PGS_E_TOOLKIT; Bit 3: (value 8) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_MISS_EARTH; Bit 4: (value 16) PGS_CSC_GetFOV_Pixel() gave PGSTD_E_SC_TAG_UNKNOWN; Bit 5: (value 32) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_ZERO_PIXEL_VECTOR; Bit 6: (value 64) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_BAD_EPH_FOR_PIXEL; Bit 7: (value 128) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_INSTRUMENT_OFF_BOARD; Bit 8: (value 256) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_BAD_ACCURACY_FLAG; Bit 9: (value 512) PGS_CSC_GetFOV_Pixel() gave PGSCSC_E_BAD_ARRAY_SIZE; Bit 10: (value 1024) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_DEFAULT_EARTH_MODEL; Bit 11: (value 2048) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_DATA_FILE_MISSING; Bit 12: (value 4096) PGS_CSC_GetFOV_Pixel() gave PGSCSC_E_NEG_OR_ZERO_RAD; Bit 13: (value 8192) PGS_CSC_GetFOV_Pixel() gave PGSMEM_E_NO_MEMORY; Bit 14: (value 16384) PGS_CSC_GetFOV_Pixel() gave PGSTD_E_NO_LEAP_SECS; Bit 15: (value 32768) PGS_CSC_GetFOV_Pixel() gave PGSTD_E_TIME_FMT_ERROR; Bit 16: (value 65536) PGS_CSC_GetFOV_Pixel() gave PGSTD_E_TIME_VALUE_ERROR; Bit 17: (value 131072) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_PREDICTED_UT1; Bit 18: (value 262144) PGS_CSC_GetFOV_Pixel() gave PGSTD_E_NO_UT1_VALUE; Bit 19: (value 524288) PGS_CSC_GetFOV_Pixel() gave PGS_E_TOOLKIT; Bit 20: (value 1048576) PGS_CSC_GetFOV_Pixel() gave PGSEPH_E_BAD_EPHEM_FILE_HDR; Bit 21: (value 2097152) PGS_CSC_GetFOV_Pixel() gave PGSEPH_E_NO_SC_EPHEM_FILE; Bit 22-31: not used
zengeoqa	16-bit unsigned integer	None	Satellite zenith Geolocation QA flags: Bit 0: (LSB, value 1) (Spacecraft) bad input value; Bit 1: (value 2) PGS_CSC_ZenithAzimuth(S/C) gave PGSCSC_W_BELOW_HORIZON; Bit 2: (value 4) PGS_CSC_ZenithAzimuth(S/C) gave PGSCSC_W_UNDEFINED_AZIMUTH; Bit 3: (value 8) PGS_CSC_ZenithAzimuth(S/C) gave PGSCSC_W_NO_REFRACTION; Bit 4: (value 16) PGS_CSC_ZenithAzimuth(S/C)

			gave PGSCSC_E_INVALID_VECTAG; Bit 5: (value 32) PGS_CSC_ZenithAzimuth(S/C) gave PGSCSC_E_LOOK_PT_ALTIT_RANGE; Bit 6: (value 64) PGS_CSC_ZenithAzimuth(S/C) gave PGSCSC_E_ZERO_INPUT_VECTOR; Bit 7: (value 128) PGS_CSC_ZenithAzimuth(S/C) gave PGS_E_TOOLKIT; Bit 8: (value 256) (Sun) bad input value; Bit 9: (value 512) (suppressed) PGS_CSC_ZenithAzimuth(Sun) gave PGSCSC_W_BELOW_HORIZON (This is not an error condition - the sun is below the horizon at night); Bit 10: (value 1024) PGS_CSC_ZenithAzimuth(Sun) gave PGSCSC_W_UNDEFINED_AZIMUTH; Bit 11: (value 2048) PGS_CSC_ZenithAzimuth(Sun) gave PGSCSC_W_NO_REFRACTION; Bit 12: (value 4096) PGS_CSC_ZenithAzimuth(Sun) gave PGSCSC_E_INVALID_VECTAG; Bit 13: (value 8192) PGS_CSC_ZenithAzimuth(Sun) gave PGSCSC_E_LOOK_PT_ALTIT_RANGE; Bit 14: (value 16384) PGS_CSC_ZenithAzimuth(Sun) gave PGSCSC_E_ZERO_INPUT_VECTOR; Bit 15: (value 32768) PGS_CSC_ZenithAzimuth(Sun) gave PGS_E_TOOLKIT
demgeoqa	16-bit unsigned integer	None	Digital Elevation Model (DEM) Geolocation QA flags: Bit 0: (LSB, value 1) bad input value; Bit 1: (value 2) Could not allocate memory; Bit 2: (value 4) Too close to North or South pole. Excluded. (This is not an error condition - a different model is used); Bit 3: (value 8) Layer resolution incompatibility. Excluded; Bit 4: (value 16) Any DEM Routine (elev) gave PGSDEM_E_IMPROPER_TAG; Bit 5: (value 32) Any DEM Routine (elev) gave PGSDEM_E_CANNOT_ACCESS_DATA; Bit 6: (value 64) Any DEM Routine (land/water) gave PGSDEM_E_IMPROPER_TAG; Bit 7: (value 128) Any DEM Routine (land/water) gave PGSDEM_E_CANNOT_ACCESS_DATA; Bit 8: (value 256) Reserved for future layers; Bit 9: (value 512) Reserved for future layers; Bit 10: (value 1024) PGS_DEM_GetRegion(elev) gave PGSDEM_M_FILLVALUE_INCLUDED; Bit 11: (value 2048) PGS_DEM_GetRegion(land/water) gave PGSDEM_M_FILLVALUE_INCLUDED; Bit 12: (value 4096) Reserved for future layers; Bit 13: (value 8192) PGS_DEM_GetRegion(all) gave PGSDEM_M_MULTIPLE_RESOLUTIONS; Bit 14: (value 16384) PGS_CSC_GetFOV_Pixel() gave any 'W' class return code except PGSCSC_W_PREDICTED_UT1; Bit 15: (value 32768) PGS_CSC_GetFOV_Pixel() gave any 'E' class return code
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 N GEO)

	point		
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
latAIRS	32-bit floating-point	AIRSTrack (= 3) * AIRSXTrack (= 3)	Geodetic center latitude of AIRS spots in degrees North (-90.0 ... 90.0)
lonAIRS	32-bit floating-point	AIRSTrack (= 3) * AIRSXTrack (= 3)	Geodetic center longitude of AIRS spots in degrees East (-180.0 ... 180.0)
Qual_Guess_PSurf	16-bit unsigned integer	None	Quality flag for surface pressure guess input.0: Highest Quality -- from timely forecast; 1: Good Quality -- from climatology; 2: Do Not Use
PSurfStd	32-bit floating-point	None	Surface pressure first guess in mbar, interpolated from forecast
nSurfStd	32-bit integer	None	Index in pressStd array of first pressure level above mean surface (1 ... 15)
Press_mid_top_bndry	32-bit floating-point	None	Pressure level in mbar, at and above which the quality of the temperature profile is given by Qual_Temp_Profile_top. Below this level use Qual_Temp_Profile_mid.
nStd_mid_top_bndry	16-bit integer	None	Index of nearest standard pressure level nearest Press_mid_top_bndry (1 ... 28)
Press_bot_mid_bndry	32-bit floating-point	None	Pressure level in mbar, at and below which the quality of the temperature profile is given by Qual_Temp_Profile_bot. Above this level use Qual_Temp_Profile_mid.
nStd_bot_mid_bndry	16-bit integer	None	Index of nearest standard pressure level nearest Press_bot_mid_bndry (1 ... 28)
PBest	32-bit floating-point	None	Maximum value of pressure for which temperature is Quality = 0 (mbar)
PGood	32-bit floating-point	None	Maximum value of pressure for which temperature is Quality = 0 or 1 (mbar)
nBestStd	16-bit integer	None	Standard level index of highest pressure (i.e. lowest altitude)for which Quality = 0. A value of 29 indicates that no part of the profile passes the test. (1 ... 29)
nGoodStd	16-bit integer	None	Standard level index of highest pressure (i.e. lowest altitude)for which Quality = 0 or 1. A value of 29 indicates that no part of the profile passes the test. (1 ... 29)

Qual_Temp_Profile_Top	16-bit unsigned integer	None	Quality flag for temperature profile at and above Press_mid_top_bndry mbar. 0: Highest Quality; 1: Good Quality; 2: Do Not Use
Qual_Temp_Profile_Mid	16-bit unsigned integer	None	Quality flag for temperature profile below Press_mid_top_bndry mbar and above Press_bot_mid_bndry mbar. 0: Highest Quality; 1: Good Quality; 2: Do Not Use
Qual_Temp_Profile_Bot	16-bit unsigned integer	None	Quality flag for temperature profile at and below Press_bot_mid_bndry mbar, including surface air temperature. 0: Highest Quality; 1: Good Quality; 2: Do Not Use
TAirStd	32-bit floating-point	StdPressureLev (= 28)	Atmospheric Temperature at StdPressLev in Kelvins. Value at 1-based index of nSurfStd may be an unphysical extrapolated value for a pressure level below the surface. Use TSurfAir for the surface air temperature.
TAirStdErr	32-bit floating-point	StdPressureLev (= 28)	Error estimate for TAirStd
TSurfAir	32-bit floating-point	None	Surface air temperature in Kelvins
TSurfAirErr	32-bit floating-point	None	Error estimate for TSurfAir
Qual_Surf	16-bit unsigned integer	None	Overall quality flag for surface fields including surface temperature, emissivity, and reflectivity. 0: Highest Quality; 1: Good Quality; 2: Do Not Use
TSurfStd	32-bit floating-point	None	Surface skin temperature in Kelvins
TSurfStdErr	32-bit floating-point	None	Error estimate for TSurfStd
numHingeSurf	16-bit integer	None	Number of IR hinge points for surface emissivity and reflectivity
freqEmis	32-bit floating-point	HingeSurf (= 100)	Frequencies for surface emissivity and reflectivity in cm-1 (in order of increasing frequency. Only first numHingeSurf elements are valid)
emisIRStd	32-bit floating-point	HingeSurf (= 100)	Spectral IR Surface Emissivities (in order of increasing frequency. Only first numHingeSurf elements are valid)
emisIRStdErr	32-bit floating-point	HingeSurf (= 100)	Error estimate for emisIRStd
Qual_MW_Only_Temp_Strat	16-bit unsigned integer	None	Overall quality flag for MW-Only temperature fields for altitudes above 201 mbar. 0: Highest Quality; 1: Good Quality; 2: Do Not Use
Qual_MW_Only_Temp_Tropo	16-bit unsigned integer	None	Overall quality flag for MW-Only temperature fields for altitudes at and below 201 mbar, including surface temperature. 0: Highest Quality; 1: Good Quality; 2: Do Not Use
TAirMWOnlyStd	32-bit floating-point	StdPressureLev (= 28)	Atmospheric Temperature retrieved using only MW information (no IR) at StdPressLev in Kelvins. Value at 1-based index of nSurfStd may be an unphysical extrapolated value for a pressure level below the surface.
MWSurfClass	8-bit integer	None	Surface class from microwave (MW) information: 0 for coastline (Liquid water covers 50-99% of area);

			1 for land (Liquid water covers < 50% of area); 2 for ocean (Liquid water covers > 99% of area); 3 for sea ice (High MW emissivity); 4 for sea ice (Low MW emissivity); 5 for snow (Higher-frequency MW scattering); 6 for glacier/snow (Very low-frequency MW scattering); 7 for snow (Lower-frequency MW scattering); -1 for unknown (not attempted)
sfcTbMWStd	32-bit floating-point	MWHingeSurf (= 7)	Microwave surface brightness (Kelvins) (Emitted radiance only, reflected radiance not included. Product of MW only algorithm)
EmisMWStd	32-bit floating-point	MWHingeSurf (= 7)	Spectral MW emissivity at the 7 MW frequencies listed for dimension MWHingeSurf (Product of MW only algorithm)
EmisMWStdErr	32-bit floating-point	MWHingeSurf (= 7)	Error estimate for EmisMWStd
Qual_MW_Only_H2O	16-bit unsigned integer	None	Quality flag for MW-Only water fields; 0: Highest Quality -- Use both column totals (totH2OMWOnlyStd and totCldH2OStd) and profiles in support product (H2OCDMWOnly and lwCDSup); 1: Good Quality -- Use column totals but not profiles; 2: Do Not Use
totH2OMWOnlyStd	32-bit floating-point	None	Total precipitable water vapor from MW-only retrieval (no IR information used) (kg / m**2)
Qual_H2O	16-bit unsigned integer	None	Overall quality flag for water vapor fields. 0: Highest Quality; 1: Good Quality; 2: Do Not Use
H2OMMRStd	32-bit floating-point	H2OPressureLay (= 14)	Water Vapor Mass Mixing Ratio (gm / kg dry air)
H2OMMRStdErr	32-bit floating-point	H2OPressureLay (= 14)	Error estimate for H2OMMRStd
totH2OStd	32-bit floating-point	None	Total precipitable water vapor (kg / m**2)
totH2OStdErr	32-bit floating-point	None	Error estimate for totH2OStd
H2OMMRSat	32-bit floating-point	H2OPressureLay (= 14)	Water vapor saturation mass mixing ratio (gm / kg dry air) over equilibrium phase
H2OMMRSat_liquid	32-bit floating-point	H2OPressureLay (= 14)	Water vapor saturation mass mixing ratio (gm / kg dry air) over liquid phase
num_H2O_Func	16-bit integer	None	Number of valid entries in each dimension of H2O_ave_kern.
H2O_verticality	32-bit floating-point	H2OFunc (= 11)	Sum of the rows of H2O_ave_kern.
Qual_O3	16-bit unsigned integer	None	Quality flag for ozone. 0: Highest Quality; 1: Good Quality; 2: Do Not Use
totO3Std	32-bit floating-point	None	Total ozone burden (Dobson units)
totO3StdErr	32-bit floating-point	None	Error estimate for totO3Std
O3VMRStd	32-bit floating-	StdPressureLay (= 28)	Ozone Volume Mixing Ratio (vmr)

	point		
O3VMRStdErr	32-bit floating-point	StdPressureLay (= 28)	Error estimate for O3VMRStd
num_O3_Func	16-bit integer	None	Number of valid entries in each dimension of O3_ave_kern.
O3_verticality	32-bit floating-point	O3Func (= 9)	Sum of the rows of O3_ave_kern.
Qual_CO	16-bit unsigned integer	None	Quality flag for carbon monoxide. 0: Highest Quality; 1: Good Quality; 2: Do Not Use
CO_total_column	32-bit floating-point	None	Retrieved total column CO (molecules/cm2).
num_CO_Func	16-bit integer	None	Number of valid entries in each dimension of CO_ave_kern.
CO_eff_press	32-bit floating-point	COFunc (= 9)	CO effective pressure for the center of each trapezoid
CO_VMR_eff	32-bit floating-point	COFunc (= 9)	Effective CO volume mixing ratio for each trapezoid.
CO_VMR_eff_err	32-bit floating-point	COFunc (= 9)	Error estimate for CO_VMR_eff
CO_verticality	32-bit floating-point	COFunc (= 9)	Sum of the rows of CO_ave_kern.
CO_dof	32-bit floating-point	None	Measure of the amount of information in CO retrieval (deg of freedom).
Qual_CH4	16-bit unsigned integer	None	Quality flag for methane. 0: Highest Quality; 1: Good Quality; 2: Do Not Use
CH4_total_column	32-bit floating-point	None	Retrieved total column CH4 (molecules/cm2).
num_CH4_Func	16-bit integer	None	Number of valid entries in each dimension of CH4_ave_kern.
CH4_eff_press	32-bit floating-point	CH4Func (= 7)	CH4 effective pressure for the center of each trapezoid
CH4_VMR_eff	32-bit floating-point	CH4Func (= 7)	Effective CH4 volume mixing ratio for each trapezoid.
CH4_VMR_eff_err	32-bit floating-point	CH4Func (= 7)	Error estimate for CH4_VMR_eff
CH4_verticality	32-bit floating-point	CH4Func (= 7)	Sum of the rows of CH4_ave_kern.
CH4_dof	32-bit floating-point	None	Measure of the amount of information in CH4 retrieval (deg of freedom).
PTropopause	32-bit floating-point	None	Tropopause height (mbar)
T_Tropopause	32-bit floating-point	None	Tropopause temperature (K)
GP_Tropopause	32-bit floating-point	None	Geopotential height at tropopause (m above mean sea level)

GP_Height	32-bit floating-point	StdPressureLev (= 28)	Geopotential Heights at StdPressureLev (m above mean sea level)
GP_Height_MWOnly	32-bit floating-point	StdPressureLev (= 28)	Geopotential Heights from MW-Only retrieval (No IR information used) at StdPressureLev (m above mean sea level)
GP_Surface	32-bit floating-point	None	Geopotential Height of surface (m above mean sea level)
Qual_Cloud_OLR	16-bit unsigned integer	None	Overall quality flag for cloud parameters and cloudy OLR. 0: Highest Quality; 1: Good Quality; 2: Do Not Use
numCloud	32-bit integer	None	Number of cloud layers
TCldTopStd	32-bit floating-point	Cloud (= 2)	Cloud top temperature in Kelvins (in order of increasing pressure. Only first numCloud elements are valid)
TCldTopStdErr	32-bit floating-point	Cloud (= 2)	Error estimate for TCldTopStd
PCldTopStd	32-bit floating-point	Cloud (= 2)	Cloud top pressure in mbar
PCldTopStdErr	32-bit floating-point	Cloud (= 2)	Error estimate for PCldTopStd
CldFrcStd	32-bit floating-point	AIRSTrack (= 3) * AIRSXTrack (= 3) * Cloud (= 2)	Cloud fraction (0.0 ... 1.0) assuming unit cloud top emissivity (in order of increasing pressure. Only first numCloud elements are valid) Caution: For Qual_Cloud_OLR = 1, only the average cloud fraction over the nine spots is reported (duplicated nine times) for each level.
CldFrcStdErr	32-bit floating-point	AIRSTrack (= 3) * AIRSXTrack (= 3) * Cloud (= 2)	Error estimate for CldFrcStd
olr	32-bit floating-point	None	Outgoing Longwave Radiation Flux integrated over 2 to 2800 cm**-1 (Watts/m**2)
olr_err	32-bit floating-point	None	Error estimate for olr (Watts/m**2)
Qual_clrolr	16-bit unsigned integer	None	Quality flag for clrolr. 0: Highest Quality; 1: Good Quality; 2: Do Not Use
clrolr	32-bit floating-point	None	Clear-sky Outgoing Longwave Radiation Flux integrated over 2 to 2800 cm**-1 (Watts/m**2)
clrolr_err	32-bit floating-point	None	Error estimate for clrolr (Watts/m**2)
dust_flag	16-bit integer	AIRSTrack (= 3) * AIRSXTrack (= 3)	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
spectral_clear_indicator	16-bit integer	AIRSTrack (= 3) * AIRSXTrack (= 3)	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
num_clear_spectral_indicator	16-bit integer	None	Number of 9 IR FOVs which are clear according to spectral_clear_indicator. -1 when the spectral clear indicator could not be applied to any of the spots. Note that the spectral clear indicator is not validated for land scenes.
CC_noise_eff_amp_factor	32-bit floating-point	None	Effective amplification of noise in IR window channels due to extrapolation in cloud clearing and uncertainty of clear state. (< 1.0 for noise reduction, >1.0 for noise amplification, -9999.0 for unknown)
CC1_noise_eff_amp_factor	32-bit floating-point	None	Equivalent of CC_noise_eff_amp_factor but from the first attempt at cloud clearing
totCldH2OStd	32-bit floating-point	None	Total cloud liquid water in kg/m**2
totCldH2OStdErr	32-bit floating-point	None	Error estimate for totCldH2OStd (unitless fraction of totCldH2OStd)
CC1_Resid	32-bit floating-point	None	Internal retrieval quality indicator -- residual between the first cloud cleared radiances for channels used in the determination and the radiances calculated from the best estimate of clear, in K
CCfinal_Resid	32-bit floating-point	None	Internal retrieval quality indicator -- residual between the final cloud cleared radiances for channels used in the determination and the radiances calculated from the best estimate of clear, in K
CCfinal_Noise_Amp	32-bit floating-point	None	Internal retrieval quality indicator -- noise amplification factor from cloud clearing because of extrapolation, dimensionless. Note: the name is misleading: this is the value after the second cloud clearing iteration, not the last.
Tdiff_IR_MW_ret	32-bit floating-point	None	Internal retrieval quality indicator -- layer mean difference in lower atmosphere between final IR temperature retrieval and the last internal MW-only temperature determination. High values suggest problems with MW or problems with cloud clearing.
Tdiff_IR_4CC1	32-bit floating-point	None	Internal retrieval quality indicator -- layer mean difference in lower atmosphere between final IR temperature retrieval and the temperature used in the first cloud clearing.
TSurfdiff_IR_4CC1	32-bit floating-point	None	Internal retrieval quality indicator -- absolute value of surface temperature difference between final IR retrieval and the surface temperature used as input in the first cloud clearing.
TSurfdiff_IR_4CC2	32-bit floating-point	None	Internal retrieval quality indicator -- absolute value of surface temperature difference between final IR retrieval and the surface temperature used as input in the second cloud clearing.
AMSU_Chans_Resid	32-bit floating-point	None	Internal retrieval quality indicator -- residual of selected AMSU channels (currently channel 5 only) against that calculated from the final IR retrieval state, K. High values suggest lower atmosphere retrieval disagrees with MW due to problems with MW or cloud clearing.
TotCld_4_CCfinal	32-bit floating-point	None	Internal retrieval quality indicator -- total cloud fraction estimated before final cloud clearing (as seen from above), dimensionless between zero and one
Surf_Resid_Ratio	32-bit	None	Internal retrieval quality indicator -- residuals of

	floating-point		surface channels as compared to predicted uncertainty (dimensionless factor)
Temp_Resid_Ratio	32-bit floating-point	None	Internal retrieval quality indicator -- residuals of temperature channels as compared to predicted uncertainty (dimensionless factor)
Water_Resid_Ratio	32-bit floating-point	None	Internal retrieval quality indicator -- residuals of water channels as compared to predicted uncertainty (dimensionless factor)
Cloud_Resid_Ratio	32-bit floating-point	None	Internal retrieval quality indicator -- residuals of cloud channels as compared to predicted uncertainty (dimensionless factor)
O3_Resid_Ratio	32-bit floating-point	None	Internal retrieval quality indicator -- residuals of ozone channels as compared to predicted uncertainty (dimensionless factor)
CO_Resid_Ratio	32-bit floating-point	None	Internal retrieval quality indicator -- residuals of carbon monoxide channels as compared to predicted uncertainty (dimensionless factor)
CH4_Resid_Ratio	32-bit floating-point	None	Internal retrieval quality indicator -- residuals of methane channels as compared to predicted uncertainty (dimensionless factor)
MWCheck_Resid_Ratio	32-bit floating-point	None	Internal retrieval quality indicator -- residuals of channels used in MW check as compared to predicted uncertainty (dimensionless factor)
O3_dof	32-bit floating-point	None	Measure of the amount of information in O3 retrieval (deg of freedom).
all_spots_avg	8-bit integer	None	1: the cloud clearing step judged the scene to be clear enough that it averaged all spots' radiances; 0: cloud clearing was applied to the radiances; -1/255: cloud clearing not attempted
MW_ret_used	8-bit integer	None	MW-only final retrieval used
Initial_CC_score	32-bit floating-point	None	Indicator of how well the initial cloud-cleared radiances match radiances reconstructed from clear eigenvectors. (Unitless ratio; 0.33 is best possible, a 3X noise reduction; <0.8 for a very good match; <3.0 for a pretty good match; >10.0 indicates a major problem)
retrieval_type	8-bit integer	None	Deprecated -- use species-specific Qual_Xxxx flags instead. Retrieval type: 0 for full retrieval; 10 for MW + final succeeded, initial retrieval failed; 20 for MW + initial succeeded, final failed; 30 for only MW stage succeeded, initial + final retrieval failed; 40 for MW + initial succeeded, final cloud-clearing failed; 50 for only MW stage succeeded, initial + final cloud-clearing failed; 100 for no retrieval;
Startup	8-bit integer	None	Source of startup input atmospheric state used in first cloud clearing step.; 0: MW-only retrieval; 1: IR-Only cloudy regression; 2: IR+MW cloudy regression, with some info from MW-only physical retrieval
RetQAFlag	16-bit unsigned integer	None	Obsolete. Use species-specific Qual_Xxx instead. Retrieval QA flags: Bit 15: spare, set to zero.;

			Bit 14 (value 16384): Ozone retrieval is suspect or rejected. (see Qual_O3 for details); Bit 13 (value 8192): Water vapor retrieval is suspect or rejected. (see Qual_H2O for details); Bit 12 (value 4096): Top part of temperature profile quality check failed or not attempted. (above Press_mid_top_bndry mbar, indices nStd_mid_top_bndry and nSup_mid_top_bndry; see Qual_Temp_Profile_Top for details); Bit 11 (value 2048): Middle part of temperature profile quality check failed or not attempted. (between Press_bot_mid_bndry and Press_top_mid_bndry mbar, indices nStd_bot_mid_bndry, nSup_bot_mid_bndry, nStd_bot_mid_bndry, and nSup_bot_mid_bndry; see Qual_Temp_Profile_Mid for details); Bit 10 (value 1024): Bottom part of temperature profile quality check failed or not attempted. (below Press_bot_mid_bndry mbar, indices nStd_bot_mid_bndry and nSup_bot_mid_bndry; see Qual_Temp_Profile_Bot for details); Bit 9 (value 512): Surface retrieval is suspect or rejected. (see Qual_Surf for details); Bit 8 (value 256): This record type not yet validated. For v4.0 all regions North of Latitude 50.0 degrees or South of Latitude -50.0 degrees will be flagged.; Bits 6-7: spare, set to zero; Bit 5 (value 32): Cloud retrieval rejected or not attempted; Bit 4 (value 16): Final retrieval rejected or not attempted; Bit 3 (value 8): Final Cloud Clearing rejected or not attempted; Bit 2 (value 4): Regression First Retrieval rejected or not attempted; Bit 1 (value 2): Initial Cloud Clearing rejected or not attempted; Bit 0 (LSB, value 1): Startup retrieval (MW-Only and/or cloudy regression depending on Startup) rejected or not attempted

4. Options for Reading Data

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.

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.

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 / AIRS2RET	√		
AIRI2CCF		√	
AIRX2SUP / AIRH2SUP	√		

5.2 AIRS data format conversion tool

GES DISC provides data format conversion service such that users will be able to download files in netCDF format as oppose to the original HDFEOS format. The netCDF files adhere to the CF-1 compliant and can easily be imported into applications or application environment such as IDV, Grads, Ferret or IDL. Like the subset service mentioned above, it is a part of the data ordering process through Mirador search engine.

6. Data Interpretation and Screen

The dimension of a full swath field is GeoXTrack=30 (cross track) by GeoTrack=45 (along track). The dimension order (in C row-major notation) is [GeoTrack, GeoXTrack, extra dimensions…]. The last index is the fastest varying in the memory.

6.1 Geolocation Coordinates

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

Time[GeoTrack, GeoXTrack] (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.

For profile parameters, the vertical dimension is expressed in terms of pressure altitude, from near surface to the top of the atmosphere (TOA). There are three categories, levels, layers and trapezoidal layers:

- Pressure levels for level quantities such as temperature profile or geopotential heights. The *pressStd* vector contains the definition of 28 pressure levels.

- Pressure layers for layer quantities such as moisture, ozone profiles. The *pressH2O* vector contains definition of 15 pressure levels, which defines 14 pressure layers.

- Trapezoidal layers for CO and CH4 profiles. The pressure at the center of the trapezoids can be obtained by reading the *CO_eff_press* and *CH4_eff_press* respectively.

All cloud parameters have a Cloud dimension, [GeoTrack, GeoXTrack, …, Cloud]. The Cloud dimension is the number of cloud layers, and is equal to 2. In 1-based array indexing scheme, Cloud index=1 refers to the upper cloud layer and Cloud index=2 is the lower cloud layer. The cloud pressure altitudes can be read from the *PcldTopStd*.

6.2 Quality Indicators

The ftptgeoqa[GeoTrack, GeoXTrack] is bit-packed QA flags for footprint geolocation. If all went well, the value should be 0.

Bit 0: (LSB, value 1) bad input value;
Bit 1: (value 2) PGS_TD_TAItoUTC() gave PGSTD_E_NO_LEAP_SECS;
Bit 2: (value 4) PGS_TD_TAItoUTC() gave PGS_E_TOOLKIT;
Bit 3: (value 8) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_MISS_EARTH;
Bit 4: (value 16) PGS_CSC_GetFOV_Pixel() gave PGSTD_E_SC_TAG_UNKNOWN;
Bit 5: (value 32) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_ZERO_PIXEL_VECTOR;
Bit 6: (value 64) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_BAD_EPH_FOR_PIXEL;
Bit 7: (value 128) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_INSTRUMENT_OFF_BOARD;
Bit 8: (value 256) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_BAD_ACCURACY_FLAG;
Bit 9: (value 512) PGS_CSC_GetFOV_Pixel() gave PGSCSC_E_BAD_ARRAY_SIZE;
Bit 10: (value 1024) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_DEFAULT_EARTH_MODEL;
Bit 11: (value 2048) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_DATA_FILE_MISSING;
Bit 12: (value 4096) PGS_CSC_GetFOV_Pixel() gave PGSCSC_E_NEG_OR_ZERO_RAD;
Bit 13: (value 8192) PGS_CSC_GetFOV_Pixel() gave PGSMEM_E_NO_MEMORY;
Bit 14: (value 16384) PGS_CSC_GetFOV_Pixel() gave PGSTD_E_NO_LEAP_SECS;
Bit 15: (value 32768) PGS_CSC_GetFOV_Pixel() gave PGSTD_E_TIME_FMT_ERROR;
Bit 16: (value 65536) PGS_CSC_GetFOV_Pixel() gave PGSTD_E_TIME_VALUE_ERROR;
Bit 17: (value 131072) PGS_CSC_GetFOV_Pixel() gave PGSCSC_W_PREDICTED_UT1;
Bit 18: (value 262144) PGS_CSC_GetFOV_Pixel() gave PGSTD_E_NO_UT1_VALUE;
Bit 19: (value 524288) PGS_CSC_GetFOV_Pixel() gave PGS_E_TOOLKIT;
Bit 20: (value 1048576) PGS_CSC_GetFOV_Pixel() gave PGSEPH_E_BAD_EPHEM_FILE_HDR;
Bit 21: (value 2097152) PGS_CSC_GetFOV_Pixel() gave PGSEPH_E_NO_SC_EPHEM_FILE;
Bit 22-31: not used

To understand QA fields and caveats, please consult the Level-2 Standard Product QuickStart guide. In particular, all users must read the sections describing the Standard Temperature Product and the Standard Moisture Product. Information appearing in these two sections is critically important to proper understanding and use of the other standard products in research. The following is the table of contents of the quickstart guide:

Description
Type of Product
Quality Indicators
Caveats
Suggestions for Researchers
Recommended Papers
Recommended Supplemental User Documentation

6.3 Error Estimates

For information on error estimates, please read the Quality Control and Error Estimation document.

LEVEL 2 QUALITY INDICATORS
Introduction
Level 2 MW-Only Retrieval Quality Indicators
MW-Only Temperature Profile Quality Indicators
MW-Only Moisture Profile and Cloud Liquid Water Quality Indicator
Level 2 Combined IR/MW Retrieval Quality Indicators
Temperature Profile Quality Indicators
Quality Indicators for Other Retrieved Parameters
Special Note for Users of Moisture Profile Products

COMBINED IR/MW RETRIEVAL ERROR ESTIMATION
HOW COMBINED IR/MW QUALITY CONTROL IS SET UPON COMPLETION OF FINAL RETRIEVAL
Preliminary Determinations
Qual_Temp_Profile_Top
Qual_Temp_Profile_Mid
Qual_Temp_Profile_Bot
Qual_Surf
Qual_H2O
Qual_O3
Qual_CO
Qual_CH4
Qual_CO2
Qual_Cloud_OLR
Qual_clrolr
Qual_CC_Rad
Qual_Precip_Est
Qual_Clim_Ind

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

Mailing Address:
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