National Aeronautics and Space Administration
Goddard Earth Science Data Information and
Services Center (GES DISC)

NASA Advanced Technology Microwave Sounder (ATMS) Level 1B Data Product User Guide

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Product Version 2.11

Software Version 2.11.2

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Revision History

Product Version	Software Version	Date	Changes
		2015-08-19	Initial Internal Release
		2016-04-06	Beta Release
v01_08	v01_08_00	2017-04	Version 1 Release
v02_05	v02_05_00	2018-05	Version 2 Release - Update Geolocation - Completed implementation of all L1a QA definitions - Updated Correction Coefficients - Re-designed calib_degraded quality flag - Added a brightness temperature status flag: antenna_temp_qc.
v02_11	v02_11_02		Version 2 Release - Added support for JPSS-1 - Updated some hyperlinks - Added list of acronyms

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1.0 Introduction

This document provides basic information about Version 2.11 of the Advanced Technology Microwave Sounder (ATMS) Level 1B (L1B) product. The ATMS instrument is on both the Suomi-National Polar-orbiting Partnership (S-NPP) and the Joint Polar Satellite System - 1 (JPSS-1) / National Oceanic and Atmospheric Administration - 20 (NOAA-20) satellites.

The ATMS Level 1B product consists of calibrated radiances (antenna is geolocated and calibrated to antenna temperature. This product has been annotated with both file and attribute level metadata to fully describe its contents.

The ATMS Level 1A product is not described in detail in this document.

The JPSS-1 / NOAA-20 satellite will be referred to as JPSS-1 or J1 throughout this document. NOAA-20 is used in NOAA documentation.

1.1 Overview of Sounder SIPS

The Joint Polar Satellite System (JPSS) S-NPP Sounder Science Investigator-led Processing Systems (SIPS), is one of six SIPSs formed by National Aeronautics and Space Adminstration (NASA) to provide the processing of level 0 data through level 1, level 2 and level 3 from the Soumi-NPP (previously known as NPP) satellite. The Suomi-NPP and JPSS-1 satellites are managed by the National Polar-orbiting Partnership (NPP) which includes elements from NASA, NOAA and Department of Defense (DoD). Specific details about the S-NPP and JPSS Missions can be found at:
https://www.jpss.noaa.gov/mission_and_instruments.html.

The S-NPP and JPSS-1 Sounder SIPS is a team made up of the Jet Propulsion Laboratory (JPL) and the Goddard Earth Sciences Data and Information Services Center (GES DISC). JPL provides the overall project management, science algorithm software integration, test and validation support. The GES DISC performs level 0 data acquisition and routine data processing operations. The GES DISC / Distributed Active Archive Center (DAAC) archives and distributes the data products and associated documentation.

Table 1.1 S-NPP / JPSS-1 SIPSs.

Science Team	SIPS	Instrument(s) Analyzed
Sounder	Sounder	ATMS and CrIS
Ozone	Ozone	OMPS
Ceres	CERES CARS	CERES
Land	Land	VIIRS
Atmospheres	Atmospheres	VIIRS
Ocean	Ocean	VIIRS

The SIPSs may also develop additional products to help their science teams analyze the potential usefulness of S-NPP products for continuing ongoing climate studies. Consequently, most SIPSs produce a variety of data products for their science teams. Because the possibility exists that many of these data products provide utility to the science community beyond the S-NPP science teams, NASA requests that SIPS products be made available to the public. This is consistent with NASA's Earth Science Data Policy https://science.nasa.gov/earth-science/earth-science-data/data-information-policy

1.2 Mission Instrument Description

S-NPP is the first in a series of next generation U.S. weather satellites of the JPSS. ATMS is one of 5 instruments onboard the S-NPP satellite. The other instruments are: Clouds and the Earth's Radiant Energy System (CERES), Cross-track Infrared Sounder (CrIS), Ozone Mapping and Profiler Suite (OMPS) and Visible Infrared Imaging Radiometer Suite (VIIRS). These same 5 instruments are also flying onboard JPSS-1.

ATMS is a 22-channel microwave, cross-track scanning sounder providing both temperature and humidity soundings. Table 1.2.1and Table 1.2.2 contain a summary of the ATMS instrument and platform parameters.

The ATMS instrument's Scan Drive Mechanism on S-NPP has been experiencing additional wear on the bearings. To extend the life of the instrument, a decision was made to perform scan reversals for the purpose of 're-wetting' the bearings. The scan reversals are now occurring twice per orbit, starting Aug 9, 2016. The end result of this maneuver is a slight loss of data. This loss of data is represented by the use of Fill Values.

Table 1.2.1 Instrument parameters for ATMS on S-NPP and JPSS-1.

Instrument Type	Scan Rate (s)	Scan Range (°)	Scan Pattern	FOR Dia (km, nadir)	Spectral Channels
Microwave (MW)	8/3	±53	96	16-75	22

Table 1.2.2 Approximate orbital parameters.

Platform	Alt (km)	Orbit Incl. (°)	Equator X Time	Period	Repeat Orbits	Repeat Days	Launch
S-NPP	824	98.7	13:30	101	228	16	28 Oct 2011
JPSS-1	824	98.7	13:30	101	228	16	18 Nov 2017

1.3 Data Disclaimer

Version 2.11 ATMS Level 1B data are released to the public as is. Every effort has been made to properly represent the data for which this document describes.

1.4 Obtaining the Product

The ATMS Level 1A & 1B software is written and integrated by the Sounder SIPS. The software then gets delivered to the Goddard Earth Sciences Data and Information Services Center (GES DISC) where it's installed and put into Operations. The ATMS Level 1B product can be found at and downloaded from the GES DISC. There you will find additional information and documentation about this product and other products of interest.

https://disc.gsfc.nasa.gov

Use the ECS Shortnames in the search string to quickly find the ATMS Level 1B product:

SNPP: SNPPATMSL1B
JPSS-1/NOAA-20:   SNDRJ1ATMSL1B

or the links below will take you directly to the Level 1B products:

SNPP: https://disc.gsfc.nasa.gov/datasets?keywords=SNPPATMSL1B&page=1
JPSS-1:   https://disc.gsfc.nasa.gov/datasets?keywords=SNDRJ1ATMSL1B&page=1

1.5 Contact Information

For information, questions or concerns with this ATMS L1B data set, please contact: Ruth Monarrez at Ruth.Monarrez@jpl.nasa.gov or send your question to: sounder.sips@jpl.nasa.gov.

1.6 References

1. B. Lambrigsten, Suomi National Polar Partnership Mission; Algorithm Theoretical Basis Document NASA L1b: Advanced Technology Microwave Sounder, Version 1, July 2004

2. M. Schreier, Advanced Technology Microwave Sounder (ATMS) Assessment Report for Suomi National Polar-orbiting Partnership (S-NPP) Sounder Science Investigator-led Processing System (SIPS) Data Level 1, Data Product Version 2.0, March 2018

3. NOAA Technical Report NESDIS 143 Cross Track Infrared Sounder (CrIS) Sensor Data Record (SDR) User's Guide. Version 1.0, Washington, D.C., December, 2013

4. NASA ESO EARTHDATA Standards, Requirements and References, <https://earthdata.nasa.gov/user-resources/standards-and-references>

5. NASA ESO EARTHDATA Data Levels,

<https://earthdata.nasa.gov/collaborate/open-data-services-and-software/data-information-policy/data-levels>

1.7 What's different/new in Version 2

What is new in version 2.11:

- Software Version 2.11.2 releases the JPSS-1/NOAA-20 ATMS Level 1B product for the first time.

- Fixed an anomaly that was causing failure in earlier processing resulting in degraded qa_pct_data_missing in Level 1B.

2.0 ATMS Level 1B Product Overview

The ATMS Level 1B product is generated using L0 data that has been processed by the Earth Observing System (EOS) Data and Operations System (EDOS) located at NASA's Goddard Earth Sciences Data and Information Services Center (GES DISC). An ATMS Level 1A product is produced as an interim product but is not archived and distributed publicly.

The ATMS Level 1B product consists of calibrated radiances and geolocation along with any metadata necessary to use and interpret this product.

2.1 Product Granulation and Identification

The ATMS product is divided into a series of 6-minute segments or granules with each granule making up one file and 240 granules per day. Each file contains all observations for a given type made during a period of exactly 6 minutes. For each day, each 240 files are identified by granule number in the filename. For example, **g156** for granule 156 out of 240.

The nominal start time of granule 1 is defined to be 00:00:00. Because both CrIS and ATMS instruments are synced to International Atomic Time (TAI), the start time of the first 8-second scanset of a day can be anywhere up to 8 seconds later. It moves 1 second with each leap second. If the first scanset starts 8 seconds after the nominal start time, then the data can extend up to 8 seconds past the nominal end time.

The ability to uniquely identify a granule is built in to the ATMS L1B product. This is extremely useful when publishing analysis results. The nominal time coverage, represented as a string: yyyymmddThhmm, is used to construct a unique granule identifier called "gran_id". gran_id is stored as a global attribute that is also used in the filename, see section 2.6 File Naming Convention.

In addition, there is an observation identifier variable called "obs_id" that can further uniquely identify an observation within the granule. The obs_id is formatted as the gran_id with observation information appended to it.

The format of obs_id is: yyyymmddThhmm.aaaExx where 'aaa' is the 3-digit along-track index (001 – 135) and xx is the cross-track index (01 – 96). The "E" indicates earth view.

Example of obs_id: 20170401T2354.001E01

2.2 Algorithm Background

The Sounder SIPS ATMS L1B data products are a product of processing NASA Level 0 data through Level 1A/Geolocation and Level 1B. See Figure 1. For a definition of the NASA Data

Processing Levels go to: https://science.nasa.gov/earth-science/earth-science-data/data-processing-levels-for-eosdis-data-products

The ATMS Level 1A processing extracts radiance counts from ATMS science telemetry, converts engineering counts from the health and status telemetries into physical measurements such as temperatures.

The L1A geolocation processing derives spacecraft positions and attitude according to spacecraft diary telemetry. It also projects ATMS sounding field-of-views (FOV) onto the topographic surface with geolocation, line-of-site (LOS) view angles, solar angles, and surface parameters such as elevations and land fractions. All the geolocation parameters from L1A processing are propagated to the L1B product.

The L1B processing then applies calibration coefficients (gain and offset) and non-linearity correction to the radiance counts to convert them to antenna temperatures. For more detail on how the calibration coefficients and the non-linearity corrections are computed can be found in Appendix A.

Technical and scientific details of the L1B processing steps and calibrations can be found in the Algorithm Theoretical Basis Document, NASA L1b: Advanced Technology Microwave Sounder Algorithm Theoretical Basis Document (ATBD) [Reference 1].
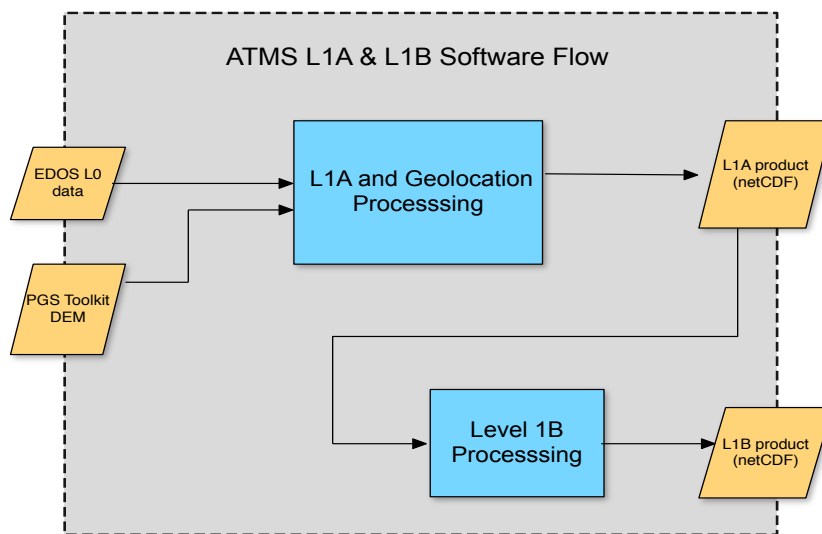
Figure 1. Sounder SIPS processing development cycle.

2.3 Data Organization

The ATMS products are divided into a series of 6 minute segments with one segment per 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 (also known as granules), identified by the granule number in the filename. For granule start time details, refer to section 2.1.

2.4 File Format and Structure

The ATMS L1B files, similar to the CrIS L1B files, are in Network Common Data Form, version 4 / Hierarchical Data Format version 5 (NetCDF4/HDF5) format.

The product format takes advantage of the NetCDF4 data model and makes use of groups, dimensions, variables and attributes to fully describe the science data. Below is a basic structure of a l1b datafile.

```
netcdf l1b_atms {
      dimensions:
      // global attributes:
      variables:
      group: aux {
            variables:
      } // aux
} // l1b_atms
```

2.5 Metadata

Every effort has been made to ensure that metadata conforms to the Climate and Forecasting (CF), Version 1.6, and Attribute Conventions for Data Discovery (ACDD), Version 1.3, guidelines.

See the full product specification in Appendix C.

For more information on CF, refer to:
http://cfconventions.org/Data/cf-documents/requirements-recommendations/requirements-recommendations-1.6.html

For more information on ACDD, refer to:

http://wiki.esipfed.org/index.php/Attribute_Convention_for_Data_Discovery_1-3

2.6 Missing Data / Fill Values

On occasion, there will be data that is missing for whatever reason. In the situation where there are incomplete granules within the 6-minute product granule, the missing data will be filled with a 'Fill Values'. The fill value is indicated by the attribute '_FillValue'. The fill value will exist in the same location the missing data would exist. This will preserve the shape of the 6-minute granule. Should the data for an entire 6-minute granule be missing, a granule will still be produced and will contain all fill values. In other words, a full fill-value granule will be produced. With this in mind, it is advised to check the data for fill values before it is used. The fill values per variable datatype are listed in the table below.

Table: 3.6.1 Fill Values

Variable Type	Fill Value
ubyte	255UB
ushort	65535US
uint	4294967295U
float	9.96921e+36f
double	9.96920996838687e+36

At the scan level, the ATMS L1B Program Generation Executive (PGE) tries to calculate antenna temperature for all scans, even there is not enough information to calculate scan-specific calibration coefficients. If we can't calculate coefficients for a particular scan, but we do have science counts for this scan, then we use calibration coefficients from the nearest, earlier scan. If we don't have good coefficients from the earlier scan, we use nearest coefficients from the later scan. So, in fact, if we can calculate a calibration coefficients for any scan within a 10 minute interval from a current scan, we will calculate a 'degraded' antenna temperature for a current scan. The PGE sets the corresponding quality flags if the antenna temperature for a scan was calculated using calibration coefficients from a different scan.

2.7 File Naming Convention

File naming for Sounder SIPS products will be unique and include the following tokens separated by the delimiter '.' For each token that makes up the filename, there will be an attribute in the data product that it maps to (see Table 2.6 Filenaming).

Filename tokens:
<Sounder_SIPS_ID>.<platform>.<inst_ID>.<granuleID>.<product_granularity>.<granule_number>.<product_type>.<variant>.<version>.<production_location>.<prod_timestamp>.<extension>

Where

- **Sounder_SIPS_ID** = project identifier <product_name_project> = SNDR
- **platform** <product_name_platform> = SNPP, J1
- **inst_ID** <product_name_instr> = ATMS
- **granuleID** (yyyymmddThhmm) <gran_id> nominal start time where:
  - yyyy = year
  - mm = month of year (01-12)
  - dd = day of month (01-31)
  - hh = hour (00-24)
  - mm = minute (00-59)
- **product_granularity** <product_name_duration> = m06 (6 minute)
- **granule_number** <granule_number> = g###
- **product_type** with an optional identifier for testing <product_type_name_id>
  - L1B for ATMS Level 1B
- **variant** <product_name_variant> = std
- **version** vmm_mm <product_name_version> - eg. v02_00
  - Versioning will be synchronized across Sounder SIPS products
- **production_location** <product_name_producer>- J=SIPS at JPL, G=Operations at GES DISC, T=Test, W = CrIS Level 1 Team at Univ of Wisc
- **prod_timestamp** = product creation time ensures product has a unique name (yymmddhhmmss) <product_name_timestamp>- 150407123456
- **Extension** (.nc)

Table 2.6 ATMS Fileanaming

Filename token	Attribute name in CDF (mapping)	Format	Value(s)	Notes
Sounder_SIPS_ID	product_name_project	text	SNDR	Sounder SIPS project ID
platform	product_name_platform	text	SNPP, J1	Satellite platform: SNPP = Suomi-NPP, J1 = JPSS-1 / NOAA-20
inst_ID	product_name_instr	text	ATMS	Instrument identifier
granuleID	gran_id	yyyymmddThhmm		Unique granule identifier; Nominal granule start time
product_granularity	product_name_duration	m##	m06	6 minutes
granule_number	granule_number	g###	g001 - g240	Only for 6-minute granule products
product_type	product_name_type_id + optional identifier for uniqueness	Freeform text. No whitespace or any punctuation except underscore.	L1B	See: reference 5

Version	product_name_version	v02_##; v02_##_##	V02_11	e.g. v02_11; v02_11_00 (when produced at JPL)
variant	product_name_variant	Freeform text. No whitespace or any punctuation except underscore.	std	Used to identify special runs. The default is: std = standard.
production_locat ion	product_name_producer		J, G, T, W	J: Jet Propulsion Laboratory G: Goddard Space Flight Center T: Test W: University of Wisconsin
prod_timestamp	product_name_timestam p	yymmddhhmmss		Time the file was produced
product_name_e xtension	product_name_extension		nc	NetCDF file extension

Example Filename: 6-minute ATMS Level 1B granule
SNDR.SNPP.ATMS.*yyyymmdd*T*hhmm*.m06.g196.L1B.std.v*mm_mm*.G.*yymmddhhmmss*.nc
SNDR.SNPP.ATMS.20150407T0906.m06.g196.L1B.std.v02_05.G.150407104359.nc

SNDR.J1.ATMS.*yyyymmdd*T*hhmm*.m06.g196.L1B.std.v*mm_mm*.G.*yymmddhhmmss*.nc
SNDR.J1.ATMS.20180407T0906.m06.g196.L1B.std.v02_05.G.180407103459.nc

2.8 Time Representation

Times in the ATMS L1B product are generally represented as UTC. However, observation times are provided in both UTC and TAI93 representations as a convenience to users. Coordinated Universal Time (UTC) is the international standard for representation of time. UTC times are expressed in human-readable form, as a set of values indicating year, month, day, hour and so on. In the data stream received from the satellite, observation times are represented as UTC.

Timestamps in ATMS L1B product filenames and attributes are represented as UTC and formatted according to the "ISO 8601:2004" standard. For example, the time January 25, 2016 at 13:00 may be represented as either of the following:

<div align="center">

2016-01-25T13:00Z
20160125T1300

</div>

The longer form is used in attributes, and the more compact form is used in filenames. The character "Z" indicates "Zulu time", or UTC.

International Atomic Time (TAI) is expressed as number of seconds elapsed on the surface of the Earth since some reference UTC time. The term "TAI93" indicates that the reference time is the beginning of the year 1993, or 1993-01-01T00:00:00Z. This reference time was chosen to be consistent with data products from other instruments, and to allow for precise representation of times spanning the expected mission length.

Leap seconds are one-second adjustments that are occasionally applied to UTC as 23:59:60, to account for irregularities in the rotation of the Earth. There were 27 leap seconds applied to UTC between Jan 1, 1958 and Jan 1, 1993. Between Jan 1, 1993 and Jan 1, 2017, an additional 10 leap seconds were applied to UTC. Leap seconds must be accounted for when doing certain kinds of time calculations, especially in astronomy and satellite applications. Leap seconds can occur on December 31 or June 30 of a given year, and are announced months in advance.

Leap seconds must be accounted for in the following operations:

> • When calculating exact elapsed time between two UTC times. If one or more leap seconds were inserted between the UTC endpoints, they must be accounted for in order for the result to be accurate.

> • When converting between UTC and TAI times. Any leap seconds that occurred between the TAI reference time and the UTC time must be accounted for, or the result will be wrong.

> • When comparing TAI times with different reference times, or converting from one TAI reference time to the other. Any leap seconds that occurred between the reference times must be accounted for, or the result will be wrong. An example would be when comparing TAI93 times in L1B products to "IET" microseconds in operational ATMS SDR products, which use a reference time of 1958-01-01T00:00Z. In this case 27 leap seconds occurred between the reference times.

In general, these operations can be error-prone. Therefore it is recommended that time calculations and conversions be done with leap-second-aware third party tools that rely on an up-to-date table of leap seconds, such as the "astropy" python package. As a generality, it can be assumed that most computational systems use POSIX time scale and cannot represent leap seconds, unless specifically stated in the software specifications.

3.0 Data Content

The ATMS Level 1B data products are written in NetCDF4 format and therefore make use of groups, dimensions, variables and attributes (global & variable). Every NetCDF4/HDF5 file contains, at a minimum, one root group which is unnamed.

Attention should be given to quality flags and checked for fill values before being used for any analysis or higher processing of the L1B product.

Selected groups and fields are highlighted in this section. A full profile of the contents of the files is included in a Common Data Language (CDL) output file in Appendix C.

3.1 Dimensions

Global dimensions used throughout the ATMS L1B products.

Table 3.1 Global Dimensions

Dimension name	Size	Meaning
atrack	135	Along-track spatial dimension
xtrack	96	Cross-track spatial dimension
channel	22	ATMS channels
band	5	Microwave bands: K, Ka, V, W, G
utc_tuple	8	Parts of the UTC date/time: year, month, day, hour, minute, second, millisec, microsec
spatial	3	Directions: x, y, z
fov_poly	8	Lat/lon points defining the polygon bounding an fov (anticlockwise as viewed from above)
attitude	3	Roll, pitch, yaw
spacetrack	4	Space view

3.2 Global Attributes

There are two types of attributes: global & variable. In this section we will talk about global attributes. Global attributes, sometimes referred to as 'file-level attributes', provide information about the entire file or 6-minute granule. This includes observation times, publisher and creator information, data provenance, geolocation information, etc. Many attributes are required to conform to the CF & ACDD standards while other attributes are

written for consistency with legacy products, hence, you may find some information to be a little redundant or differing in the naming convention.

There are some QA global attributes that should be considered before using the data in analysis or processing. See Table 3.2.1 QA Related Global Attributes, if AutomaticQualityFlag equals 'Suspect', you should look at other QA fields such as qa_pct_data_missing to see what percent of the data may be missing and decide to use the data or not. See Table 3.2.2 Global Attributes or Appendix C: CDL File Definition for full file definition.

Table 3.2.1 QA Related Global Attributes

Attribute Name	Type	Dimension	Description
AutomaticQualityFlag	string		**Passed**: the granule contains a non-degraded calibrated brightness temperature or radiance for at least one channel in a geolocated FOV **Suspect**: the granule does not qualify as "Passed" but contains a (possibly degraded) calibrated brightness temperature or radiance for at least one channel (possibly without associated geolocation) **Failed**: the granule contains no calibrated brightness temperatures/radiances.
geo_qual	ushort	atrack, xtrack	Overall value of 0 indicates no critical issues. Bit 2 (surface_loc)- Failed geolocation on Earth topographic surface Bit 3 (DEM) - Could not set FOV surface elevations and land water fraction Bit 4 (geoid_loc) - Failed geolocation on Earth geoid Bit 5 (solar_ang) - Failed to set solar zenith or azimuth angles Bit 6 (spacecraft_ang) - Failed to set spacecraft zenith or azimuth angles Bit 7 - Unused (0) Bit 8 (band_specific) - Failed geolocation of some bands
qa_pct_data_missing	float		Percentage of expected observations that are missing.
qa_pct_data_geo	float		Percentage of expected observations that are successfully geolocated.

qa_pct_data_sci_mode	float		Percentage of expected observations that were taken while the instrument was in science mode and are successfully geolocated.
qa_no_data	string		A simple indicator of whether this is an "empty" granule with no data from the instrument. "TRUE" or "FALSE".

A full definition of the global attributes can be found in Appendix C: CDL File Definition.

Table 3.2.2 Global Attributes

Name	Type	Description
keywords	string	A comma-separated list of key words and/or phrases. Keywords may be common words or phrases, terms from a controlled vocabulary (GCMD is often used), or URIs for terms from a controlled vocabulary (see also "keywords_vocabulary" attribute).
Conventions	string	A comma-separated list of the conventions that are followed by the dataset.
history	string	Provides an audit trail for modifications to the original data. This attribute is also in the NetCDF Users Guide: 'This is a character array with a line for each invocation of a program that has modified the dataset. Well-behaved generic netCDF applications should append a line containing: date, time of day, user name, program name and command arguments.' To include a more complete description you can append a reference to an ISO Lineage entity; see NOAA EDM ISO Lineage guidance.
source	string	The method of production of the original data. If it was model-generated, source should name the model and its version. If it is observational, source should characterize it. This attribute is defined in the CF Conventions. Examples: 'temperature from CTD #1234'; 'world model v.0.1'.
processing_level	string	A textual description of the processing (or quality control) level of the data.
product_name_type_id	string	Product name as it appears in product_name (L1A, L1B, L2, SNO_AIRS_CrIS)
comment	string	Miscellaneous information about the data or methods used to produce it. Can be empty.
acknowledgment	string	A place to acknowledge various types of support for the project that produced this data.

Name	Type	Description
license	string	Provide the URL to a standard or specific license, enter "Freely Distributed" or "None", or describe any restrictions to data access and distribution in free text.
standard_name_vocabulary	string	The name and version of the controlled vocabulary from which variable standard names are taken. (Values for any standard_name attribute must come from the CF Standard Names vocabulary for the data file or product to comply with CF.) Example: 'CF Standard Name Table v27'.
date_created	string	The date on which this version of the data was created. (Modification of values implies a new version, hence this would be assigned the date of the most recent values modification.) Metadata changes are not considered when assigning the date_created. The ISO 8601:2004 extended date format is recommended, as described in the Attribute Content Guidance section.
creator_name	string	The name of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.
creator_email	string	The email address of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.
creator_url	string	The URL of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.
institution	string	Processing facility that produced this file
project	string	The name of the project(s) principally responsible for originating this data. Multiple projects can be separated by commas, as described under Attribute Content Guidelines. Examples: 'PATMOS-X', 'Extended Continental Shelf Project'.
product_name_project	string	The name of the project as it appears in the file name. 'SNDR' for all Sounder SIPS products, even AIRS products.
publisher_name	string	The name of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.
publisher_email	string	The email address of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.

Name	Type	Description
publisher_url	string	The URL of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.
geospatial_bounds	string	Describes the data's 2D or 3D geospatial extent in OGC's Well-Known Text (WKT) Geometry format (reference the OGC Simple Feature Access (SFA) specification). The meaning and order of values for each point's coordinates depends on the coordinate reference system (CRS). The ACDD default is 2D geometry in the EPSG:4326 coordinate reference system. The default may be overridden with geospatial_bounds_crs and geospatial_bounds_vertical_crs (see those attributes). EPSG:4326 coordinate values are latitude (decimal degrees_north) and longitude (decimal degrees_east), in that order. Longitude values in the default case are limited to the -180, 180) range. Example: 'POLYGON ((40.26 -111.29, 41.26 -111.29, 41.26 -110.29, 40.26 -110.29, 40.26 -111.29))'.
geospatial_bounds_crs	string	The coordinate reference system (CRS) of the point coordinates in the geospatial_bounds attribute. This CRS may be 2-dimensional or 3-dimensional, but together with geospatial_bounds_vertical_crs, if that attribute is supplied, must match the dimensionality, order, and meaning of point coordinate values in the geospatial_bounds attribute. If geospatial_bounds_vertical_crs is also present then this attribute must only specify a 2D CRS. EPSG CRSs are strongly recommended. If this attribute is not specified, the CRS is assumed to be EPSG:4326. Examples: 'EPSG:4979' (the 3D WGS84 CRS), 'EPSG:4047'.
geospatial_lat_min	float	Describes a simple lower latitude limit; may be part of a 2- or 3-dimensional bounding region. Geospatial_lat_min specifies the southernmost latitude covered by the dataset.
geospatial_lat_max	float	Describes a simple upper latitude limit; may be part of a 2- or 3-dimensional bounding region. Geospatial_lat_max specifies the northernmost latitude covered by the dataset.
geospatial_lon_min	float	Describes a simple longitude limit; may be part of a 2- or 3-dimensional bounding region. geospatial_lon_min specifies the westernmost longitude covered by the dataset. See also geospatial_lon_max.
geospatial_lon_max	float	Describes a simple longitude limit; may be part of a 2- or 3-dimensional bounding region. geospatial_lon_max specifies the easternmost longitude covered by the dataset. Cases where geospatial_lon_min is greater than geospatial_lon_max indicate the bounding box extends from geospatial_lon_max,

Name	Type	Description
		through the longitude range discontinuity meridian (either the antimeridian for -180:180 values, or Prime Meridian for 0:360 values), to geospatial_lon_min; for example, geospatial_lon_min=170 and geospatial_lon_max=-175 incorporates 15 degrees of longitude (ranges 170 to 180 and -180 to -175).
time_coverage_start	string	Nominal start time. Describes the time of the first data point in the data set. Use the ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_of_first_valid_obs	string	Describes the time of the first valid data point in the data set. Use the ISO 8601:2004 date extended format.
time_coverage_mid	string	Describes the midpoint between the nominal start and end times. Use the ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_coverage_end	string	Nominal end time. Describes the time of the last data point in the data set. Use ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_of_last_valid_obs	string	Describes the time of the last valid data point in the data set. Use the ISO 8601:2004 date extended format.
time_coverage_duration	string	Describes the duration of the data set. Use ISO 8601:2004 duration format, preferably the extended format as recommended in the Attribute Content Guidance section.
product_name_duration	string	Product duration as it appears in product_name (m06 means six minutes)
creator_type	string	Specifies type of creator with one of the following: 'person', 'group', 'institution', or 'position'. If this attribute is not specified, the creator is assumed to be a person.
creator_institution	string	The institution of the creator; should uniquely identify the creator's institution. This attribute's value should be specified even if it matches the value of publisher_institution, or if creator_type is institution.
product_version	string	Version identifier of the data file or product as assigned by the data creator. For example, a new algorithm or methodology could result in a new product_version.
keywords_vocabulary	string	If you are using a controlled vocabulary for the words/phrases in your "keywords" attribute, this is the unique name or identifier of the vocabulary from which

Name	Type	Description
		keywords are taken. If more than one keyword vocabulary is used, each may be presented with a prefix and a following comma, so that keywords may optionally be prefixed with the controlled vocabulary key. Example: 'GCMD:GCMD Keywords, CF:NetCDF COARDS Climate and Forecast Standard Names'.
platform	string	Name of the platform(s) that supported the sensor data used to create this data set or product. Platforms can be of any type, including satellite, ship, station, aircraft or other. Indicate controlled vocabulary used in platform_vocabulary.
platform_vocabulary	string	Controlled vocabulary for the names used in the "platform" attribute.
product_name_platform	string	Platform name as it appears in product_name
instrument	string	Name of the contributing instrument(s) or sensor(s) used to create this data set or product. Indicate controlled vocabulary used in instrument_vocabulary.
instrument_vocabulary	string	Controlled vocabulary for the names used in the "instrument" attribute.
product_name_instr	string	Instrument name as it appears in product_name
product_name	string	Canonical fully qualified product name (official file name)
product_name_variant	string	Processing variant identifier as it appears in product_name. 'std' (shorthand for 'standard') is to be the default and should be what is seen in all public products.
product_name_version	string	Version number as it appears in product_name (v01_00_00)
product_name_producer	string	Production facility as it appears in product_name (single character) 'T' is the default, for unofficial local test products
product_name_timestamp	string	Processing timestamp as it appears in product_name (yymmddhhmmss)
product_name_extension	string	File extension as it appears in product_name (typically nc)
granule_number	ushort	granule number of day (1-240)
product_name_granule_number	string	zero-padded string for granule number of day (g001-g240)
gran_id	string	Unique granule identifier yyyymmddThhmm of granule start, including year, month, day, hour, and minute of granule start time
geospatial_lat_mid	float	granule center latitude
geospatial_lon_mid	float	granule center longitude
featureType	string	structure of data in file

Name	Type	Description
data_structure	string	a character string indicating the internal organization of the data with currently allowed values of 'grid', 'station', 'trajectory', or 'swath'. The 'structure' here generally describes the horizontal structure and in all cases data may also be functions, for example, of a vertical coordinate and/or time. (If using CMOR pass this in a call to cmor_set_cur_dataset_attribute.)
cdm_data_type	string	The data type, as derived from Unidata's Common Data Model Scientific Data types and understood by THREDDS. (This is a THREDDS "dataType", and is different from the CF NetCDF attribute 'featureType', which indicates a Discrete Sampling Geometry file in CF.)
id	string	An identifier for the data set, provided by and unique within its naming authority. The combination of the "naming authority" and the "id" should be globally unique, but the id can be globally unique by itself also. IDs can be URLs, URNs, DOIs, meaningful text strings, a local key, or any other unique string of characters. The id should not include white space characters.
naming_authority	string	The organization that provides the initial id (see above) for the dataset. The naming authority should be uniquely specified by this attribute. We recommend using reverse-DNS naming for the naming authority; URIs are also acceptable. Example: 'edu.ucar.unidata'.
identifier_product_doi	string	digital signature
identifier_product_doi_authority	string	digital signature source
algorithm_version	string	The version of the algorithm in whatever format is selected by the developers. Versions from multiple sub-algorithms may be concatenated with semicolon separators. (ex: 'CCAST 4.2; BB emis from MIT 2016-04-01')
production_host	string	Identifying information about the host computer for this run. (Output of linux "uname -a" command.)
format_version	string	Format version.
input_file_names	string	Semicolon-separated list of names or unique identifiers of files that were used to make this product. There will always be one space after each semicolon. There is no final semicolon.
input_file_types	string	Semicolon-separated list of tags giving the role of each input file in input_file_names. There will always be one space after each semicolon. There is no final semicolon.

Name	Type	Description
input_file_dates	string	Semicolon-separated list of creation dates for each input file in input_file_names. There will always be one space after each semicolon. There is no final semicolon.
orbitDirection	string	Orbit is ascending and/or descending. Values are "Ascending" or "Descending" if the entire granule fits that description. "NorthPole" and "SouthPole" are used for polar-crossing granules. "NA" is used when a determination cannot be made.
day_night_flag	string	Data is day or night. "Day" means subsatellite point for all valid scans has solar zenith angle less than 90 degrees. "Night" means subsatellite point for all valid scans has solar zenith angle greater than 90 degrees. "Both" means the dataset contains valid observations with solar zenith angle above and below 90 degrees. "NA" means a value could not be determined.
AutomaticQualityFlag	string	"Passed": the granule contains a non-degraded calibrated brightness temperature, radiance, or retrieved value for at least one value in a geolocated FOV; "Suspect": the granule does not qualify as "Passed" but contains a (possibly degraded) calibrated or retrieved value (possibly without associated geolocation); "Failed": the granule contains no calibrated or retrieved values.
qa_pct_data_missing	float	Percentage of expected observations that are missing.
qa_pct_data_geo	float	Percentage of expected observations that are successfully geolocated.
qa_pct_data_sci_mode	float	Percentage of expected observations that were taken while the instrument was in science mode and are successfully geolocated.
qa_no_data	string	A simple indicator of whether this is an "empty" granule with no data from the instrument. "TRUE" or "FALSE".
title	string	a succinct description of what is in the dataset. (= ECS long name)
summary	string	A paragraph describing the dataset, analogous to an abstract for a paper.
shortname	string	ECS Short Name
product_group	string	The group name to be used for this product when it is collected in a multi-group file type, like SNO or calsub.
metadata_link	string	A URL that gives the location of more complete metadata. A persistent URL is recommended for this attribute.
references	string	ATDB and design documents describing processing algorithms. Can be empty.

Name	Type	Description
contributor_name	string	The names of any individuals or institutions that contributed to the creation of this data.
contributor_role	string	The roles of any individuals or institutions that contributed to the creation of this data.

3.3 Variable Attributes

Each variable has its own associated attributes. Variable attributes are mostly a CF or ACDD standard and are used to describe the variable in more detail to properly interpret its value. See section 2.5 Metadata for a link to get more detailed information about the attributes conforming to CF and ACDD standards.

Table 3.3: Variable Attributes

Attribute	Relevant standard(s)	Description
units	CF, UDUNITS	units, for variables that represent physical quantities
_FillValue	CF, NetCDF	a single sentinel value indicating the data point contains fill instead of valid data
standard_name	CF	standard name from the CF standard name table, if one exists for the quantity being represented
long_name	CF	a longer name describing the quantity being represented, suitable for a plot title
valid_range	CF	a pair of values indicating the minimum and maximum values to be considered valid
coordinates	CF	a space-separated list of the names of other variables that are coordinates for this variable
description		a longer description of the quantity being represented
coverage_content_type	ACDD, ISO 19115-1	indicates the source of the data
ancillary_variables	CF	a space-separated list of the names of other variables that contain information about this variable
bounds	CF	defines the extent, for cell variables
cell_methods	CF	describes statistical methods used to derive data, for cell variables

flag_values	CF	a comma-separated list of flag values, for variables that represent flags
flag_meanings	CF	a space separated list of the meanings of each flag value, for variables that represent flags
flag_masks	CF	a comma-separated list of flag masks, for variables that represent flags. If this attribute is present, the basic rule is "apply the flag mask and if you get the flag value, it means the flag meaning"

3.4 Science Variables

Science data fields are in the variables group within the netCDF file. These fields are the most heavily used. Included in this group are satellite and solar geometry information, spacecraft position and orbital characteristics, surface information and related metadata.

Table 3.4.1 Science Data Variables

Variable Name	Dimensions	Type	Description	Units
obs_id	atrack, xtrack	string	unique earth view observation identifier: yyyymmddThhmm.aa[a]Exx . Includes gran_id plus two- or three-digit along-track index (01-45 or 001-135) and 2-digit cross-track index (01-96).	
instrument_state	atrack, xtrack	ubyte	instrument/data state: 0/'Process' - Data is usable for science; 1/'Special' - Observations are valid but instrument is not configured for science data (ex: stare mode); 2/'Erroneous' - Data is not usable (ex: checksum error); 3/'Missing' - No data was received.	
obs_time_tai93	atrack, xtrack	double	earth view observation midtime for each FOV	seconds since 1993-01-01 00:00
obs_time_utc	atrack, xtrack, utc_tuple	uint16	UTC earth view observation time as an array of integers: year, month, day, hour, minute, second, millisec, microsec	
lat	atrack, xtrack	float	terrain corrected latitude of FOV center	degrees_north
lat_geoid	atrack, xtrack	float	latitude of FOV center on the geoid (without terrain correction)	degrees_north
lon	atrack, xtrack	float	terrain corrected longitude of FOV center	degrees_east
lon_geoid	atrack, xtrack	float	longitude of FOV center on the geoid (without terrain correction)	degrees_east

land_frac	atrack, xtrack	float	land fraction over the FOV	unitless
surf_alt	atrack, xtrack	float	mean surface altitude wrt earth model over the FOV	m
surf_alt_sdev	atrack, xtrack	float	standard deviation of surface altitude within the FOV	m
sun_glint_lat	atrack	float	sun glint spot latitude at scan_mid_time. Fill for night observations.	degrees_north
sun_glint_lon	atrack	float	sun glint spot longitude at scan_mid_time. Fill for night observations.	degrees_east
sol_zen	atrack, xtrack	float	solar zenith angle at the center of the spot	degree
sol_azi	atrack, xtrack	float	solar azimuth angle at the center of the spot (clockwise from North)	degree
sun_glint_dist	atrack, xtrack	float	distance of sun glint spot to the center of the spot. Fill for night observations.	m
view_ang	atrack, xtrack	float	off nadir pointing angle	degree
sat_zen	atrack, xtrack	float	satellite zenith angle at the center of the spot	degree
sat_azi	atrack, xtrack	float	satellite azimuth angle at the center of the spot (clockwise from North)	degree
sat_range	atrack, xtrack	float	line of sight distance between satellite and spot center	m
asc_flag	atrack	ubyte	ascending orbit flag: 1 if ascending, 0 descending	
subsat_lat	atrack	float	sub-satellite latitude at scan_mid_time	degrees_north
subsat_lon	atrack	float	sub-satellite longitude at scan_mid_time	degrees_east
scan_mid_time	atrack	double	TAI93 at middle of earth scene scans	seconds since 1993-01-01 00:00

sat_alt	atrack	float	satellite altitude with respect to earth model at scan_mid_time	m
sat_pos	atrack, spatial	float	satellite ECR position at scan_mid_time	m
sat_vel	atrack, spatial	float	satellite ECR velocity at scan_mid_time	m s-1
sat_att	atrack, attitude	float	satellite attitude at scan_mid_time. An orthogonal triad. First element is angle about the +x (roll) ORB axis. +x axis is positively oriented in the direction of orbital flight. Second element is 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. Third element is 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.	degree
moon_ang	atrack, spacextrack	float	angle between moon and FOV center for space view	degree
local_solar_time	atrack, xtrack	float	local apparent solar time in hours from midnight	hours
mean_anom_wrt_equat	atrack	float	spacecraft mean anomaly measured with respect to the ascending node	degree
sat_sol_zen	atrack	float	solar zenith angle at the satellite	degree

sat_sol_azi	atrack	float	solar azimuth angle at the satellite (clockwise from North)	degree
asc_node_lon		float	Longitude of the last ascending node of spacecraft orbit before time_coverage_end.	degrees_east
asc_node_tai93		double	TAI93 time of the last ascending node of spacecraft orbit before time_coverage_end.	seconds since 1993-01-01 00:00
asc_node_local_solar_time		float	local apparent solar time at the last ascending node before time_coverage_end in hours from midnight	hours
solar_beta_angle		float	Beta angle for the spacecraft orbit, determining the percentage of the orbit that the spacecraft is in direct sunlight.	degree
attitude_lbl	attitude	string	list of rotational directions (roll, pitch, yaw)	
spatial_lbl	spatial	string	list of spatial directions (X, Y, Z)	
utc_tuple_lbl	utc_tuple	string	names of the elements of UTC when it is expressed as an array of integers year,month,day,hour,minute,second, millisecond,microsecond	
band_lat	atrack, xtrack, band	float	band-specific fov center latitude	degrees_north
band_lon	atrack, xtrack, band	float	band-specific fov center longitude	degrees_east
band_land_frac	atrack, xtrack, band	float	band-specific land fraction over the fov	unitless

band_surf_alt	atrack, xtrack, band	float	band-specific mean surface altitude over the fov	m
band_geoloc_chan	band	unsigned short int	Channel used in determining the geolocation information for each band	unitless
antenna_temp	atrack, xtrack, channel	float	Calibrated scene brightness temperature for each ATMS channel and beam position. This output is the Rayleigh equivalent temperature and not the Planck blackbody equivalent temperature	Kelvin
cold_nedt	channel	float	Noise equivalent delta temperature derived from observations of cold space	Kelvin
warm_nedt	channel	float	Noise equivalent delta temperature derived from observations of the warm calibration target	Kelvin
band_lbl	band	string	List of Microwave bands (K, Ka, V, W, G)	
channel	channel	unsigned short int	Number for each channel (1-22)	unitless
chan_band	channel	string	Name of band for each channel	
antenna	channel	char	Name of antenna for each channel	
center_freq	channel	float	Channel center frequency	MHz
if_offset_1	channel	float	Offset of first intermediate frequency stage (zero for no mixing)	MHz
if_offset_2	channel	float	Offset of second intermediate frequency stage (zero for no mixing)	MHz

bandwidth	channel	float	bandwidth of sum of 1, 2, or 4 channels	MHz
polarization	channel	char	Nominal polarization: Vertical or Horizontal	
beam_width	channel	float	Nominal beam width	degree

3.5 Auxilliary Variables

The auxiliary information, provided in an aux group, is not readily used by the wider user community but is provided here for completeness.

Table 3.4.2 Aux Group - Variables

Variable Name	Dimensions	Type	Description
geo_qualflag	atrack, xtrack	int32	Bit 7 - Failed geolocation on Earth topographic surface (surface_loc)
			Bit 6 - Could not set FOV surface elevations and land water fraction (DEM)
			Bit 5 - Failed geolocation on Earth geoid (geoid_loc)
			Bit 4 - Failed to set solar zenith or azimuth angles (solar_ang)
			Bit 3 - Failed to set spacecraft zenith or azimuth angles (spacecraft_ang)
			Bit 2 - Unused (0)
			Bit 1 (LSB) - Failed geolocation of some bands (band_specific)
cal_qualflag	atrack, channel	int32	(Bit 32 is most significant. It is not used because it can cause confusion when this flag is used as a signed or unsigned integer.)
			Bit 7 : No usable calibration. Scan is not calibrated. (cal_failed)
			Bit 6 : Calibration values used from different scan. (cal_from_diff_scan)
			Bit 5: Insufficient valid shelf temperature values to use in a scan calibration. Fall-back constant shelf temperatures are used. (shelf_temp_bad)
			Bit 4: Excess noise (noise)
			Bit 3: Telemetry out of limits (telem)
			Bit 2: Spectral quality is poor (spectral)
			Bit 1 (LSB): reserved (0)

cal_space_qualflag	atrack, channel	int32	(Bit 32 is most significant. It is not used because it can cause confusion when this flag is used as a signed or unsigned integer.)
			Bit 14 : Insufficient valid space (cold calibration) observation counts to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (cold_cal_bad)
			Bit 13: Insufficient effective space temperature values to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (space_temp_bad)
			Bit 12: This scan's space view #1 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv1_bad)
			Bit 11: This scan's space view #2 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv2_bad)
			Bit 10 : This scan's space view #3 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv3_bad)
			Bit 9 : This scan's space view #4 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv4_bad)
			Bit 8: Missing moon angle for this scan's space view #1. Lunar intrusion status is unknown. (sv1_moon_unknown)
			Bit 7: Missing moon angle for this scan's space view #2. Lunar intrusion status is unknown. (sv2_moon_unknown)
			Bit 6: Missing moon angle for this scan's space view #3. Lunar intrusion status is unknown. (sv3_moon_unknown)
			Bit 5: Missing moon angle for this scan's space view #4. Lunar intrusion status is unknown. (sv4_moon_unknown)
			Bits 1-4: reserved (0)

cal_blackbody_qualflag	atrack, channel	int32	(Bit 32 is most significant. It is not used because it can cause confusion when this flag is used as a signed or unsigned integer.)
			Bit 3: Insufficient valid black body (warm calibration) observation counts to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (warm_cal_bad)
			Bit 2: Insufficient valid black body temperature readings to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (bb_temp_bad)
			Bit 1 (LSB): This scan's black body view not used. A scan-specific calibration may still be calculated using black body views from neighboring scans. (bb_bad)
offset	atrack, channel	float	Offset used in calibrating earth scene brightness temps.
gain	atrack, channel	float	Gain factor used in calibrating earth scene brightness temps.
nonlin	atrack, xtrack, channel	float	Nonlinearity correction used in calibrating earth scene brightness temps.
cold_temp	atrack, channel	float	Effective temperature of cold calibration view (space) (Tcc)
warm_temp	atrack, channel	float	Effective temperature of warm calibration view (black body) (Twc)

3.6 Geolocation

Geolocation variables are located in the file at the root level in the group named variables. They include latitudes and longitudes associated with each observation, as well as satellite and solar geometry information, spacecraft position and orbital characteristics, surface information and related metadata. Table 3.4.1 Science Variables above has the complete list of variables that includes all the geolocation variables as well. We felt it was worth calling out a few key variables here.

Geolocation parameters are used for determining location of each observation on earth.

Table 3.5.1 Geolocation Dimensions

Dimension name	Size	Meaning
atrack	135	Along-track spatial dimension
xtrack	96	Cross-track spatial dimension

And the key geolocation variables are:

Table 3.5.2 Geolocation Variables

Geolocation Variable	Dimensions	Type	Meaning
lat	atrack, xtrack	32-bit floating-point	latitude of fov center
lon	atrack, xtrack	32-bit floating-point	longitude of fov center
obs_time_tai93	atrack, xtrack	64-bit floating-point	earth view observation midtime for each fov in units of seconds since 1993-01-01T00:00:00
obs_time_utc	atrack, xtrack, utc_tuple	16-bit integer	UTC earth view observation time as an array of integers: year, month, day, hour, minute, second, msec

The geolocation quality flags are listed in Appendix B.

4.0 Options for Reading the Data

The ATMS L1B files are written in NetCDF4/HDF5. Because NetCDF4 builds upon the classic NetCDF data model using HDF5 as the storage layer, a user of the data product can take full advantage of tools and libraries readily available to access the data.

Every NetCDF4 file is considered an HDF5 file, however, not every HDF5 file is necessarily a NetCDF4 file. A limited subset of the HDF5 data model and file format features are used in NetCDF4 files. Conformance to the earlier mentioned CF & ACDD standards allows for users to take advantage of most NetCDF interfaces.

Tools and libraries for reading NetCDF4 as well as a NetCDF Users' Guide are written and maintained by Unidata and can be found online at:
> http://www.unidata.ucar.edu/software/netcdf/

There are a number of interfaces available for reading NetCDF for different programming languages including: C/C++, Fortran, Matlab, IDL, Python and Perl.

Additionally, but can also be accessed with HDF5 tools and libraries available at:
> https://www.hdfgroup.org/products/hdf5_tools/

5.0 Data Services

The ATMS Level 1B products are available to the user community via the Goddard Distributed Active Archive Center (GDAAC) also referred to as the Goddard Earth Sciences Data and Information Services Center (GES DISC). See section 1.4 Obtaining the Product of this document. There you will find additional information and documentation about this product and other products of interest. Ordering and data sub-setting tools and services

> https://disc.gsfc.nasa.gov

Use the ECS Shortnames in the search string to quickly find the ATMS Level 1B product:

    SNPP: SNPPATMSL1B
    JPSS-1:   SNDRJ1ATMSL1B

or the links below will take you directly to the Level 1B products:

SNPP: https://disc.gsfc.nasa.gov/datasets?keywords=SNPPATMSL1B&page=1
JPSS-1:   https://disc.gsfc.nasa.gov/datasets?keywords=SNDRJ1ATMSL1B&page=1

Unlike the ATMS Level 1B products, the ATMS Level 1A products are not archived at the GDAAC and therefore not made publicly available. No other Data Services are provided for these products.

6.0 Acronyms and Abbreviations

ACDD	Attribute Convention for Dataset Discovery
ATBD	Algorithm Theoretical Basis Document
ATMS	Advanced Technology Microwave Sounder
CDL	Common Data Language
CF	Climate and Forecast
CrIS	Cross-Track Infrared Sounder
DoD	Department of Defense
EDOS	EOS Data and Operations System
EOS	Earth Observing System
ESDIS	Earth Science Data and Information System
ESO	ESDIS Standards Office
FOV	Field Of View
GES DISC	Goddard Earth Science Data and Information Services Center
JPL	Jet Propulsion Laboratory
JPSS	Joint Polar Satellite System
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
SIPS	Science Investigator-led Processing Systems
S-NPP	Suomi-National Polar-orbiting Partnership
UTC	Coordinated Universal Time
VIIRS	Visible Infrared Imaging Radiometer Suite

Appendix A: Differences in implementation between Algorithm Theoretical Basis Document (ATBD) and ATMS L1B V2

A.1 Calculation of Calibration Coefficients and Non-Linearity Correction

The implementation of calculation of calibration coefficients differs from the one described in the ATBD [1] section 5.5.4 (page 37). The approach described in the ATBD does not work with the non-linearity coefficients that we have from NOAA's Interface Data Processing Segment (IDPS) calibration coefficients file. Version 2 of Level 1B PGE uses the same approach as NOAA's IDPS software. We do not calculate a_0, a_1, a_2 coefficients, instead, we calculate 'offset', 'gain' and 'non linearity correction'. The implemented algorithm is as follows:

Tb = Tbl + Q

Tbl = Twc + (Cs-Cwa)/gain
Q = Tnl*(1-4*[(Tbl-Tcc)/(Twc-Tcc) -0.5]^2)

where

Tb = Brightness temperature, as reported in antenna_temp parameter
Q = non-linearity correction
Tnl = Peak nonlinearity, as determined from calibration tests (non-linear term
        interpolated for cold plate temperature)
Tbl = Brightness temperature assuming linear transfer function
Twc = Effective temperature of warm calibration (hot target)
Cs = Number of counts for the scene sample
Cwa = Number of counts from the warm calibration view, averaged
Tcc = Brightness temperature of cold calibration (cold space view) for each channel
Ccca =Number of counts from the cold calibration view, averaged

The "offset" is the temperature used when scene counts are 0 assuming linear transfer function. We calculate offset as:

Toffset = Twc – Cwa/gain

A.2 Lunar Intrusion or Contamination

The lunar contamination threshold is a configurable parameter that is defined for each ATMS channel. If the angle between moon center and field-of-view center for space view is less than a set threshold, the count for such space view are not included in the calculation

of the averaged cold calibration counts. The lunar contamination threshold is a configurable parameter, defined for each channel. It could be changed in APF XML configuration file. This approach is different from the NOAAs IDPS handling of lunar contamination.

A.3 Smoothing of Calibration Counts

The ATBD [1] describes a triangular smoothing function for calibration counts on section 5.4 (page 34). Version 2 of the ATMS Level 1B PGE uses a rectangular smoothing function (calibration counts from 9 scans are averaged with the same weight). This is similar to what NOAA IDPS does. This is done to make a comparison with IDPS antenna temperature more straightforward. The smoothing weights are configurable parameters that are defined for each channel. They can be changed in APF XML configuration files.

A.4 Blackbody Emissivity

The black body emissivity for warm calculation black body temperature is currently set to 1 for all channels. This is the same value that NOAA IDPS uses.

Appendix B: Geolocation Quality Flags

Flag name	Bit Index	Num Bits	Meaning
geo_qualflag	7	1	Failed geolocation on Earth topographic surface (surface_loc)
	6	1	Could not set FOV surface elevations and land water fraction (DEM)
	5	1	Failed geolocation on Earth geoid (geoid_loc)
	4	1	Failed to set solar zenith or azimuth angles (solar_ang)
	3	1	Failed to set spacecraft zenith or azimuth angles (spacecraft_ang)
	2	1	Unused (0)
	1	1	(LSB) - Failed geolocation of some bands (band_specific)
cal_qualflag	32	1	(Bit 32 is most significant. It is not used because it can cause confusion when this flag is used as a signed or unsigned integer.)
	7	1	No usable calibration. Scan is not calibrated. (cal_failed)
	6	1	Calibration values used from different scan. (cal_from_diff_scan)
	5	1	Insufficient valid shelf temperature values to use in a scan calibration. Fall-back constant shelf temperatures are used. (shelf_temp_bad)
	4	1	Excess noise (noise)
	3	1	Telemetry out of limits (telem)
	2	1	Spectral quality is poor (spectral)
	1	1	(LSB): reserved (0)
cal_space_qualflag	32	1	(Bit 32 is most significant. It is not used because it can cause confusion when this flag is used as a signed or unsigned integer.)
	14	1	Insufficient valid space (cold calibration) observation counts to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (cold_cal_bad)

	13	1	Insufficient effective space temperature values to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (space_temp_bad)
	12	1	This scan's space view #1 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv1_bad)
	11	1	This scan's space view #2 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv2_bad)
	10	1	This scan's space view #3 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv3_bad)
	9	1	This scan's space view #4 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv4_bad)
	8	1	Missing moon angle for this scan's space view #1. Lunar intrusion status is unknown. (sv1_moon_unknown)
	7	1	Missing moon angle for this scan's space view #2. Lunar intrusion status is unknown. (sv2_moon_unknown)
	6	1	Missing moon angle for this scan's space view #3. Lunar intrusion status is unknown. (sv3_moon_unknown)
	5	1	Missing moon angle for this scan's space view #4. Lunar intrusion status is unknown. (sv4_moon_unknown)
	Bits 1 - 4	1	reserved (0)
cal_blackbody_qualflag	32	1	(Bit 32 is most significant. It is not used because it can cause confusion when this flag is used as a signed or unsigned integer.)
	3	1	Insufficient valid black body (warm calibration) observation counts to produce a scan-specific calibration. Scan may still be

			calibrated using coefficients from another scan. (warm_cal_bad)
	2	1	Insufficient valid black body temperature readings to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (bb_temp_bad)
	1	1	(LSB): This scan's black body view not used. A scan-specific calibration may still be calculated using black body views from neighboring scans. (bb_bad)
offset	atrack, channel	float	Offset used in calibrating earth scene brightness temps.
gain	atrack, channel	float	Gain factor used in calibrating earth scene brightness temps.
nonlin	atrack, xtrack, channel	float	Nonlinearity correction used in calibrating earth scene brightness temps.
cold_temp	atrack, channel	float	Effective temperature of cold calibration view (space) (Tcc)
warm_temp	atrack, channel	float	Effective temperature of warm calibration view (black body) (Twc)

Appendix C: S-NPP CDL File Definition

A full data product specification is generated by using the NetCDF4 library and using the ncdump utility. This produces a CDL text file showing the full structure of the ATMS L1b datafile.

The command used to generate the CDL file is: ncdump –h <filename>.nc

netcdf SNDR.SNPP.ATMS.20190101T2354.m06.g240.L1B.std.v02_11.G.190102091945 {

```
dimensions:
        spatial = 3 ;           // directions: x, y, z
        fov_poly = 8;           // lat/lon points defining the ploygon bounding an fov
                                         (anticlockwise as viewed from above)
        utc_tuple = 8 ;         // parts of UTC time
        attitude = 3 ;          // roll, pitch, yaw
        atrack = 135 ;          // along-track spatial dimension
        xtrack = 96 ;           // cross-track spatial dimension
        channel = 22 ;          // channel number
        band = 5 ;              // Microwave bands
        spacextrack = 4 ;       // space view

// global attributes:
                string :keywords = "EARTH SCIENCE > SPECTRAL/ENGINEERING > MICROWAVE > ANTENNA
TEMPERATURE" ;
                string :Conventions = "CF-1.6, ACDD-1.3" ;
                string :source = "ATMS instrument telemetry" ;
                string :processing_level = "1B" ;
                string :product_name_type_id = "L1B" ;
                string :comment = "" ;
                string :acknowledgment = "Support for this research was provided by NASA." ;
                string :standard_name_vocabulary = "CF Standard Name Table v28" ;
                string :project = "Sounder SIPS" ;
                string :product_name_project = "SNDR" ;
                string :geospatial_bounds_crs = "EPSG:4326" ;
                string :time_coverage_duration = "P0000-00-00T00:06:00" ;
                string :product_name_duration = "m06" ;
                string :creator_type = "institution" ;
                string :keywords_vocabulary = "GCMD:GCMD Keywords" ;
                string :platform = "SUOMI-NPP > Suomi National Polar-orbiting Partnership" ;
                string :platform_vocabulary = "GCMD:GCMD Keywords" ;
                string :instrument = "ATMS > Advanced Technology Microwave Sounder" ;
                string :instrument_vocabulary = "GCMD:GCMD Keywords" ;
                string :product_name_instr = "ATMS" ;
                string :product_name_extension = "nc" ;
                string :featureType = "point" ;
                string :data_structure = "swath" ;
                string :cdm_data_type = "Swath" ;
                string :format_version = "v02.00.23" ;
                string :title = "SNPP ATMS Level-1B" ;
                string :summary = "The Level-1B ATMS product includes data from the ATMS instrument for
one six-minute interval.  Data is geolocated and calibrated to antenna temperature." ;
                string :shortname = "SNPPATMSL1B" ;
                string :product_group = "l1b_atms" ;
```

string :references = "ATMS ATBD is in review. It will be published at http://eospso.gsfc.nasa.gov/content/algorithm-theoretical-basis-documents" ;
string :contributor_name = "Jet Propulsion Laboratory: Bjorn Lambrigtsen" ;
string :contributor_role = "ATMS Scientist" ;
string :history = "Created on 2019-01-02T05:26:25Z by L1A ATMS PGE at Sounder SIPS: GES DISC, v02.11.02; Created on 2019-01-02T09:19:45Z by Level 1B ATMS PGE at Sounder SIPS: GES DISC, version v02_11" ;
string :license = "Freely Distributed" ;
string :date_created = "2019-01-02T09:19:45Z" ;
string :creator_name = "Sounder SIPS: GES DISC" ;
string :creator_email = "gsfc-help-disc@lists.nasa.gov" ;
string :creator_url = "http://disc.sci.gsfc.nasa.gov/" ;
string :institution = "Goddard Space Flight Center - National Aeronautics and Space Administration" ;
string :publisher_name = "Goddard Earth Science Data and Information Services Center" ;
string :publisher_email = "gsfc-help-disc@lists.nasa.gov" ;
string :publisher_url = "http://disc.sci.gsfc.nasa.gov/" ;
string :geospatial_bounds = "POLYGON ((-53.29 30.41, -47.85 -5.45, -64.05 -30.31, -73.80 32.90, -53.29 30.41))" ;
:geospatial_lat_min = -73.80039f ;
:geospatial_lat_max = -47.85793f ;
:geospatial_lon_min = -30.31836f ;
:geospatial_lon_max = 32.90666f ;
string :time_coverage_start = "2019-01-01T23:54:00Z" ;
string :time_of_first_valid_obs = "2019-01-01T23:54:00Z" ;
string :time_coverage_mid = "2019-01-01T23:57:00Z" ;
string :time_coverage_end = "2019-01-02T00:00:00Z" ;
string :time_of_last_valid_obs = "2019-01-01T23:59:59Z" ;
string :creator_institution = "Goddard Space Flight Center - National Aeronautics and Space Administration" ;
string :product_version = "v02.11.02" ;
string :product_name_platform = "SNPP" ;
string :product_name = "SNDR.SNPP.ATMS.20190101T2354.m06.g240.L1B.std.v02_11.G.190102091945.nc" ;
string :product_name_variant = "std" ;
string :product_name_version = "v02_11" ;
string :product_name_producer = "G" ;
string :product_name_timestamp = "190102091945" ;
:granule_number = 240US ;
string :product_name_granule_number = "g240" ;
string :gran_id = "20190101T2354" ;
:geospatial_lat_mid = -60.82916f ;
:geospatial_lon_mid = 1.29415f ;
string :id = "10.5067/HFDD6A30MA10" ;
string :naming_authority = "http://dx.doi.org/" ;
string :identifier_product_doi = "10.5067/HFDD6A30MA10" ;
string :identifier_product_doi_authority = "http://dx.doi.org/" ;
string :algorithm_version = "2017-08 IDPS emulation" ;
string :production_host = "Linux gs6102dsc-snpp1.gesdisc.eosdis.nasa.gov 2.6.32-754.9.1.el6.x86_64 #1 SMP Thu Dec 6 08:02:15 UTC 2018 x86_64 x86_64 x86_64 GNU/Linux" ;
string :input_file_names = "SNPPATMSL1A.A2019001.2348.2.2019001224552.hdf; SNPPATMSL1A.A2019001.2354.2.2019002002604.hdf; SNPPATMSL1A.A2019002.0000.2.2019002002604.hdf; SNDR.SNPP.L1bMw.apf.171115000000.xml; SNDR.SNPP.L1bMw.template.180523000000.nc" ;

```
            string :input_file_types = "ATMS_L1A; ATMS_L1A; ATMS_L1A; ATMS_L1B_AlgParam;
ATMS_L1B_Template" ;
            string :input_file_dates = "2019-01-01; 2019-01-01; 2019-01-02; N/A; N/A" ;
            string :orbitDirection = "Descending" ;
            string :day_night_flag = "Both" ;
            string :AutomaticQualityFlag = "Passed" ;
            :qa_pct_data_missing = 0.f ;
            :qa_pct_data_geo = 100.f ;
            :qa_pct_data_sci_mode = 100.f ;
            string :qa_no_data = "FALSE" ;
            string :metadata_link = "http://disc.sci.gsfc.nasa.gov/" ;

variables:
      string obs_id(atrack, xtrack) ;
            string obs_id:long_name = "earth view observation id" ;
            string obs_id:description = "unique earth view observation identifier:
yyyymmddThhmm.aa[a]Exx .  Includes gran_id plus two- or three-digit along-track index (01-45 or 001-135)
and 2-digit cross-track index (01-96)." ;
            string obs_id:coverage_content_type = "referenceInformation" ;
      ubyte instrument_state(atrack, xtrack) ;
            string instrument_state:long_name = "instrument state" ;
            string instrument_state:coordinates = "lon lat" ;
            string instrument_state:description = "instrument/data state: 0/'Process' - Data is usable for
science; 1/'Special' - Observations are valid but instrument is not configured for science data (ex: stare
mode); 2/'Erroneous' - Data is not usable (ex: checksum error); 3/'Missing' - No data was received." ;
            instrument_state:_FillValue = 255UB ;
            string instrument_state:coverage_content_type = "qualityInformation" ;
            string instrument_state:flag_meanings = "Process Special Erroneous Missing" ;
            instrument_state:flag_values = 0UB, 1UB, 2UB, 3UB ;
      double obs_time_tai93(atrack, xtrack) ;
            string obs_time_tai93:units = "seconds since 1993-01-01 00:00" ;
            obs_time_tai93:valid_range = -2934835217., 3376598410. ;
            string obs_time_tai93:long_name = "earth view FOV midtime" ;
            string obs_time_tai93:standard_name = "time" ;
            string obs_time_tai93:description = "earth view observation midtime for each FOV" ;
            obs_time_tai93:_FillValue = 9.96920996838687e+36 ;
            string obs_time_tai93:coverage_content_type = "referenceInformation" ;
      ushort obs_time_utc(atrack, xtrack, utc_tuple) ;
            string obs_time_utc:long_name = "earth view UTC FOV time" ;
            string obs_time_utc:coordinates = "utc_tuple_lbl" ;
            string obs_time_utc:description = "UTC earth view observation time as an array of integers: year,
month, day, hour, minute, second, millisec, microsec" ;
            obs_time_utc:_FillValue = 65535US ;
            string obs_time_utc:coverage_content_type = "referenceInformation" ;
      float lat(atrack, xtrack) ;
            string lat:units = "degrees_north" ;
            lat:valid_range = -90.f, 90.f ;
            string lat:long_name = "latitude" ;
            string lat:standard_name = "latitude" ;
            string lat:description = "latitude of FOV center" ;
            lat:_FillValue = 9.96921e+36f ;
            string lat:coverage_content_type = "referenceInformation" ;
            string lat:bounds = "lat_bnds" ;
      float lat_geoid(atrack, xtrack) ;
            string lat_geoid:units = "degrees_north" ;
```

```
        lat_geoid:valid_range = -90.f, 90.f ;
        string lat_geoid:long_name = "latitude" ;
        string lat_geoid:standard_name = "latitude" ;
        string lat_geoid:description = "latitude of FOV center on the geoid (without terrain correction)" ;
        lat_geoid:_FillValue = 9.96921e+36f ;
        string lat_geoid:coverage_content_type = "referenceInformation" ;
float lon(atrack, xtrack) ;
        string lon:units = "degrees_east" ;
        lon:valid_range = -180.f, 180.f ;
        string lon:long_name = "longitude" ;
        string lon:standard_name = "longitude" ;
        string lon:description = "longitude of FOV center" ;
        lon:_FillValue = 9.96921e+36f ;
        string lon:coverage_content_type = "referenceInformation" ;
        string lon:bounds = "lon_bnds" ;
float lon_geoid(atrack, xtrack) ;
        string lon_geoid:units = "degrees_east" ;
        lon_geoid:valid_range = -180.f, 180.f ;
        string lon_geoid:long_name = "longitude" ;
        string lon_geoid:standard_name = "longitude" ;
        string lon_geoid:description = "longitude of FOV center on the geoid (without terrain
correction)" ;
        lon_geoid:_FillValue = 9.96921e+36f ;
        string lon_geoid:coverage_content_type = "referenceInformation" ;
float lat_bnds(atrack, xtrack, fov_poly) ;
        string lat_bnds:units = "degrees_north" ;
        lat_bnds:valid_range = -90.f, 90.f ;
        string lat_bnds:long_name = "FOV boundary latitudes" ;
        string lat_bnds:description = "latitudes of points forming a polygon around the perimeter of the
FOV" ;
        lat_bnds:_FillValue = 9.96921e+36f ;
        string lat_bnds:coverage_content_type = "referenceInformation" ;
float lon_bnds(atrack, xtrack, fov_poly) ;
        string lon_bnds:units = "degrees_east" ;
        lon_bnds:valid_range = -180.f, 180.f ;
        string lon_bnds:long_name = "FOV boundary longitudes" ;
        string lon_bnds:description = "longitudes of points forming a polygon around the perimeter of
the FOV" ;
        lon_bnds:_FillValue = 9.96921e+36f ;
        string lon_bnds:coverage_content_type = "referenceInformation" ;
float land_frac(atrack, xtrack) ;
        string land_frac:units = "1" ;
        land_frac:valid_range = 0.f, 1.f ;
        string land_frac:long_name = "land fraction" ;
        string land_frac:standard_name = "land_area_fraction" ;
        string land_frac:coordinates = "lon lat" ;
        string land_frac:description = "land fraction over the FOV" ;
        land_frac:_FillValue = 9.96921e+36f ;
        string land_frac:coverage_content_type = "referenceInformation" ;
        string land_frac:cell_methods = "area: mean (beam-weighted)" ;
float surf_alt(atrack, xtrack) ;
        string surf_alt:units = "m" ;
        string surf_alt:ancillary_variables = "surf_alt_sdev" ;
        surf_alt:valid_range = -500.f, 10000.f ;
        string surf_alt:long_name = "surface altitude" ;
```

```
        string surf_alt:standard_name = "surface_altitude" ;
        string surf_alt:coordinates = "lon lat" ;
        string surf_alt:description = "mean surface altitude wrt  earth model over the FOV" ;
        surf_alt:_FillValue = 9.96921e+36f ;
        string surf_alt:coverage_content_type = "referenceInformation" ;
        string surf_alt:cell_methods = "area: mean (beam-weighted)" ;
float surf_alt_sdev(atrack, xtrack) ;
        string surf_alt_sdev:units = "m" ;
        surf_alt_sdev:valid_range = 0.f, 10000.f ;
        string surf_alt_sdev:long_name = "surface altitude standard deviation" ;
        string surf_alt_sdev:coordinates = "lon lat" ;
        string surf_alt_sdev:description = "standard deviation of surface altitude within the FOV" ;
        surf_alt_sdev:_FillValue = 9.96921e+36f ;
        string surf_alt_sdev:coverage_content_type = "qualityInformation" ;
        string surf_alt_sdev:cell_methods = "area: standard_deviation (beam-weighted)" ;
float sun_glint_lat(atrack) ;
        string sun_glint_lat:units = "degrees_north" ;
        sun_glint_lat:valid_range = -90.f, 90.f ;
        string sun_glint_lat:long_name = "sun glint latitude" ;
        string sun_glint_lat:standard_name = "latitude" ;
        string sun_glint_lat:coordinates = "subsat_lon subsat_lat" ;
        string sun_glint_lat:description = "sun glint spot latitude at scan_mid_time.  Fill for night
observations." ;
        sun_glint_lat:_FillValue = 9.96921e+36f ;
        string sun_glint_lat:coverage_content_type = "referenceInformation" ;
float sun_glint_lon(atrack) ;
        string sun_glint_lon:units = "degrees_east" ;
        sun_glint_lon:valid_range = -180.f, 180.f ;
        string sun_glint_lon:long_name = "sun glint longitude" ;
        string sun_glint_lon:standard_name = "longitude" ;
        string sun_glint_lon:coordinates = "subsat_lon subsat_lat" ;
        string sun_glint_lon:description = "sun glint spot longitude at scan_mid_time.  Fill for night
observations." ;
        sun_glint_lon:_FillValue = 9.96921e+36f ;
        string sun_glint_lon:coverage_content_type = "referenceInformation" ;
float sol_zen(atrack, xtrack) ;
        string sol_zen:units = "degree" ;
        sol_zen:valid_range = 0.f, 180.f ;
        string sol_zen:long_name = "solar zenith angle" ;
        string sol_zen:standard_name = "solar_zenith_angle" ;
        string sol_zen:coordinates = "lon lat" ;
        string sol_zen:description = "solar zenith angle at the center of the spot" ;
        sol_zen:_FillValue = 9.96921e+36f ;
        string sol_zen:coverage_content_type = "referenceInformation" ;
float sol_azi(atrack, xtrack) ;
        string sol_azi:units = "degree" ;
        sol_azi:valid_range = 0.f, 360.f ;
        string sol_azi:long_name = "solar azimuth angle" ;
        string sol_azi:standard_name = "solar_azimuth_angle" ;
        string sol_azi:coordinates = "lon lat" ;
        string sol_azi:description = "solar azimuth angle at the center of the spot (clockwise from
North)" ;
        sol_azi:_FillValue = 9.96921e+36f ;
        string sol_azi:coverage_content_type = "referenceInformation" ;
float sun_glint_dist(atrack, xtrack) ;
```

```
        string sun_glint_dist:units = "m" ;
        sun_glint_dist:valid_range = 0.f, 3.e+07f ;
        string sun_glint_dist:long_name = "sun glint distance" ;
        string sun_glint_dist:coordinates = "lon lat" ;
        string sun_glint_dist:description = "distance of sun glint spot to the center of the spot.  Fill for
night observations." ;
        sun_glint_dist:_FillValue = 9.96921e+36f ;
        string sun_glint_dist:coverage_content_type = "referenceInformation" ;
float view_ang(atrack, xtrack) ;
        string view_ang:units = "degree" ;
        view_ang:valid_range = 0.f, 180.f ;
        string view_ang:long_name = "view angle" ;
        string view_ang:standard_name = "sensor_view_angle" ;
        string view_ang:coordinates = "lon lat" ;
        string view_ang:description = "off nadir pointing angle" ;
        view_ang:_FillValue = 9.96921e+36f ;
        string view_ang:coverage_content_type = "referenceInformation" ;
float sat_zen(atrack, xtrack) ;
        string sat_zen:units = "degree" ;
        sat_zen:valid_range = 0.f, 180.f ;
        string sat_zen:long_name = "satellite zenith angle" ;
        string sat_zen:standard_name = "sensor_zenith_angle" ;
        string sat_zen:coordinates = "lon lat" ;
        string sat_zen:description = "satellite zenith angle at the center of the spot" ;
        sat_zen:_FillValue = 9.96921e+36f ;
        string sat_zen:coverage_content_type = "referenceInformation" ;
float sat_azi(atrack, xtrack) ;
        string sat_azi:units = "degree" ;
        sat_azi:valid_range = 0.f, 360.f ;
        string sat_azi:long_name = "satellite azimuth angle" ;
        string sat_azi:standard_name = "sensor_azimuth_angle" ;
        string sat_azi:coordinates = "lon lat" ;
        string sat_azi:description = "satellite azimuth angle at the center of the spot (clockwise from
North)" ;
        sat_azi:_FillValue = 9.96921e+36f ;
        string sat_azi:coverage_content_type = "referenceInformation" ;
float sat_range(atrack, xtrack) ;
        string sat_range:units = "m" ;
        sat_range:valid_range = 100000.f, 1.e+07f ;
        string sat_range:long_name = "satellite range" ;
        string sat_range:coordinates = "lon lat" ;
        string sat_range:description = "line of sight distance between satellite and spot center" ;
        sat_range:_FillValue = 9.96921e+36f ;
        string sat_range:coverage_content_type = "referenceInformation" ;
ubyte asc_flag(atrack) ;
        asc_flag:valid_range = 0UB, 1UB ;
        string asc_flag:long_name = "ascending orbit flag" ;
        string asc_flag:coordinates = "subsat_lon subsat_lat" ;
        string asc_flag:description = "ascending orbit flag: 1 if ascending, 0 descending" ;
        asc_flag:_FillValue = 255UB ;
        string asc_flag:coverage_content_type = "referenceInformation" ;
        string asc_flag:flag_meanings = "descending ascending" ;
        asc_flag:flag_values = 0UB, 1UB ;
float subsat_lat(atrack) ;
        string subsat_lat:units = "degrees_north" ;
```

subsat_lat:valid_range = -90.f, 90.f ;
            string subsat_lat:long_name = "sub-satellite latitude" ;
            string subsat_lat:standard_name = "latitude" ;
            string subsat_lat:description = "sub-satellite latitude at scan_mid_time" ;
            subsat_lat:_FillValue = 9.96921e+36f ;
            string subsat_lat:coverage_content_type = "referenceInformation" ;
    float subsat_lon(atrack) ;
            string subsat_lon:units = "degrees_east" ;
            subsat_lon:valid_range = -180.f, 180.f ;
            string subsat_lon:long_name = "sub-satellite longitude" ;
            string subsat_lon:standard_name = "longitude" ;
            string subsat_lon:description = "sub-satellite longitude at scan_mid_time" ;
            subsat_lon:_FillValue = 9.96921e+36f ;
            string subsat_lon:coverage_content_type = "referenceInformation" ;
    double scan_mid_time(atrack) ;
            string scan_mid_time:units = "seconds since 1993-01-01 00:00" ;
            scan_mid_time:valid_range = -2934835217., 3376598410. ;
            string scan_mid_time:long_name = "midscan TAI93" ;
            string scan_mid_time:standard_name = "time" ;
            string scan_mid_time:coordinates = "subsat_lon subsat_lat" ;
            string scan_mid_time:description = "TAI93 at middle of earth scene scans" ;
            scan_mid_time:_FillValue = 9.96920996838687e+36 ;
            string scan_mid_time:coverage_content_type = "referenceInformation" ;
    float sat_alt(atrack) ;
            string sat_alt:units = "m" ;
            sat_alt:valid_range = 100000.f, 1000000.f ;
            string sat_alt:long_name = "satellite altitude" ;
            string sat_alt:standard_name = "altitude" ;
            string sat_alt:coordinates = "subsat_lon subsat_lat" ;
            string sat_alt:description = "satellite altitude with respect to earth model at scan_mid_time" ;
            sat_alt:_FillValue = 9.96921e+36f ;
            string sat_alt:coverage_content_type = "referenceInformation" ;
    float sat_pos(atrack, spatial) ;
            string sat_pos:units = "m" ;
            string sat_pos:long_name = "satellite position" ;
            string sat_pos:coordinates = "subsat_lon subsat_lat spatial_lbl" ;
            string sat_pos:description = "satellite ECR position at scan_mid_time" ;
            sat_pos:_FillValue = 9.96921e+36f ;
            string sat_pos:coverage_content_type = "referenceInformation" ;
    float sat_vel(atrack, spatial) ;
            string sat_vel:units = "m s-1" ;
            string sat_vel:long_name = "satellite velocity" ;
            string sat_vel:coordinates = "subsat_lon subsat_lat spatial_lbl" ;
            string sat_vel:description = "satellite ECR velocity at scan_mid_time" ;
            sat_vel:_FillValue = 9.96921e+36f ;
            string sat_vel:coverage_content_type = "referenceInformation" ;
    float sat_att(atrack, attitude) ;
            string sat_att:units = "degree" ;
            sat_att:valid_range = -180.f, 180.f ;
            string sat_att:long_name = "satellite attitude" ;
            string sat_att:coordinates = "subsat_lon subsat_lat angular_lbl" ;
            string sat_att:description = "satellite attitude at scan_mid_time. An orthogonal triad. First
element is angle about the +x (roll) ORB axis. +x axis is positively oriented in the direction of orbital flight.
Second element is 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. Third element is 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." ;
            sat_att:_FillValue = 9.96921e+36f ;
            string sat_att:coverage_content_type = "referenceInformation" ;
      float moon_ang(atrack, spacextrack) ;
            string moon_ang:units = "degree" ;
            moon_ang:valid_range = 0.f, 180.f ;
            string moon_ang:long_name = "moon angle" ;
            string moon_ang:coordinates = "subsat_lon subsat_lat" ;
            string moon_ang:description = "angle between moon and FOV center for space view" ;
            moon_ang:_FillValue = 9.96921e+36f ;
            string moon_ang:coverage_content_type = "referenceInformation" ;
      float local_solar_time(atrack, xtrack) ;
            string local_solar_time:units = "hours" ;
            local_solar_time:valid_range = 0.f, 24.f ;
            string local_solar_time:long_name = "local apparent solar time" ;
            string local_solar_time:coordinates = "lon lat" ;
            string local_solar_time:description = "local apparent solar time in hours from midnight" ;
            local_solar_time:_FillValue = 9.96921e+36f ;
            string local_solar_time:coverage_content_type = "referenceInformation" ;
      float mean_anom_wrt_equat(atrack) ;
            string mean_anom_wrt_equat:units = "degree" ;
            mean_anom_wrt_equat:valid_range = 0.f, 360.f ;
            string mean_anom_wrt_equat:long_name = "mean anomaly with respect to the equator" ;
            string mean_anom_wrt_equat:coordinates = "subsat_lon subsat_lat" ;
            string mean_anom_wrt_equat:description = "spacecraft mean anomaly measured with respect to the ascending node" ;
            mean_anom_wrt_equat:_FillValue = 9.96921e+36f ;
            string mean_anom_wrt_equat:coverage_content_type = "referenceInformation" ;
      float sat_sol_zen(atrack) ;
            string sat_sol_zen:units = "degree" ;
            sat_sol_zen:valid_range = 0.f, 180.f ;
            string sat_sol_zen:long_name = "satellite solar zenith" ;
            string sat_sol_zen:coordinates = "subsat_lon subsat_lat" ;
            string sat_sol_zen:description = "solar zenith angle at the satellite" ;
            sat_sol_zen:_FillValue = 9.96921e+36f ;
            string sat_sol_zen:coverage_content_type = "referenceInformation" ;
      float sat_sol_azi(atrack) ;
            string sat_sol_azi:units = "degree" ;
            sat_sol_azi:valid_range = 0.f, 360.f ;
            string sat_sol_azi:long_name = "satellite solar azimuth" ;
            string sat_sol_azi:coordinates = "subsat_lon subsat_lat" ;
            string sat_sol_azi:description = "solar azimuth angle at the satellite (clockwise from North)" ;
            sat_sol_azi:_FillValue = 9.96921e+36f ;
            string sat_sol_azi:coverage_content_type = "referenceInformation" ;
      float asc_node_lon ;
            string asc_node_lon:units = "degrees_east" ;
            asc_node_lon:valid_range = -180.f, 180.f ;
            string asc_node_lon:long_name = "ascending node" ;
            string asc_node_lon:description = "Longitude of the last ascending node of spacecraft orbit before time_coverage_end." ;
            asc_node_lon:_FillValue = 9.96921e+36f ;
            string asc_node_lon:coverage_content_type = "referenceInformation" ;
      double asc_node_tai93 ;
            string asc_node_tai93:units = "seconds since 1993-01-01 00:00" ;

```
            asc_node_tai93:valid_range = -2934835217., 3376598410. ;
            string asc_node_tai93:long_name = "ascending node time" ;
            string asc_node_tai93:description = "TAI93 time of the last ascending node of spacecraft orbit
before time_coverage_end." ;
            asc_node_tai93:_FillValue = 9.96920996838687e+36 ;
            string asc_node_tai93:coverage_content_type = "referenceInformation" ;
      float asc_node_local_solar_time ;
            string asc_node_local_solar_time:units = "hours" ;
            asc_node_local_solar_time:valid_range = 0.f, 24.f ;
            string asc_node_local_solar_time:long_name = "local apparent solar time at the ascending node" ;
            string asc_node_local_solar_time:description = "local apparent solar time at the last ascending
node before time_coverage_end in hours from midnight" ;
            asc_node_local_solar_time:_FillValue = 9.96921e+36f ;
            string asc_node_local_solar_time:coverage_content_type = "referenceInformation" ;
      float solar_beta_angle ;
            string solar_beta_angle:units = "degree" ;
            solar_beta_angle:valid_range = -90.f, 90.f ;
            string solar_beta_angle:long_name = "beta angle" ;
            string solar_beta_angle:description = "Beta angle for the spacecraft orbit, determining the
percentage of the orbit that the spacecraft is in direct sunlight." ;
            solar_beta_angle:_FillValue = 9.96921e+36f ;
            string solar_beta_angle:coverage_content_type = "referenceInformation" ;
      string attitude_lbl(attitude) ;
            string attitude_lbl:long_name = "rotational direction" ;
            string attitude_lbl:description = "list of rotational directions (roll, pitch, yaw)" ;
            string attitude_lbl:coverage_content_type = "auxiliaryInformation" ;
      string spatial_lbl(spatial) ;
            string spatial_lbl:long_name = "spatial direction" ;
            string spatial_lbl:description = "list of spatial directions (X, Y, Z)" ;
            string spatial_lbl:coverage_content_type = "auxiliaryInformation" ;
      string utc_tuple_lbl(utc_tuple) ;
            string utc_tuple_lbl:long_name = "UTC date/time parts" ;
            string utc_tuple_lbl:description = "names of the elements of UTC when it is expressed as an array
of integers year,month,day,hour,minute,second,millisecond,microsecond" ;
            string utc_tuple_lbl:coverage_content_type = "auxiliaryInformation" ;
      float band_lat(atrack, xtrack, band) ;
            string band_lat:units = "degrees_north" ;
            band_lat:valid_range = -90.f, 90.f ;
            string band_lat:long_name = "band latitude" ;
            string band_lat:standard_name = "latitude" ;
            string band_lat:description = "band-specific fov center latitude" ;
            band_lat:_FillValue = 9.96921e+36f ;
            string band_lat:coverage_content_type = "referenceInformation" ;
            string band_lat:bounds = "band_lat_bnds" ;
      float band_lon(atrack, xtrack, band) ;
            string band_lon:units = "degrees_east" ;
            band_lon:valid_range = -180.f, 180.f ;
            string band_lon:long_name = "band longitude" ;
            string band_lon:standard_name = "longitude" ;
            string band_lon:description = "band-specific fov center longitude" ;
            band_lon:_FillValue = 9.96921e+36f ;
            string band_lon:coverage_content_type = "referenceInformation" ;
            string band_lon:bounds = "band_lon_bnds" ;
      float band_lat_bnds(atrack, xtrack, band, fov_poly) ;
            string band_lat_bnds:units = "degrees_north" ;
```

```
        band_lat_bnds:valid_range = -90.f, 90.f ;
        string band_lat_bnds:long_name = "band fov boundary latitudes" ;
        string band_lat_bnds:description = "latitudes of points forming a polygon around the perimeter
of the band-specific fov" ;
        band_lat_bnds:_FillValue = 9.96921e+36f ;
        string band_lat_bnds:coverage_content_type = "referenceInformation" ;
    float band_lon_bnds(atrack, xtrack, band, fov_poly) ;
        string band_lon_bnds:units = "degrees_east" ;
        band_lon_bnds:valid_range = -180.f, 180.f ;
        string band_lon_bnds:long_name = "band fov boundary longitudes" ;
        string band_lon_bnds:description = "longitudes of points forming a polygon around the
perimeter of the band-specific fov" ;
        band_lon_bnds:_FillValue = 9.96921e+36f ;
        string band_lon_bnds:coverage_content_type = "referenceInformation" ;
    float band_land_frac(atrack, xtrack, band) ;
        string band_land_frac:units = "1" ;
        band_land_frac:valid_range = 0.f, 1.f ;
        string band_land_frac:long_name = "band land fraction" ;
        string band_land_frac:standard_name = "land_area_fraction" ;
        string band_land_frac:coordinates = "band_lbl band_lat band_lon" ;
        string band_land_frac:description = "band-specific land fraction over the fov" ;
        band_land_frac:_FillValue = 9.96921e+36f ;
        string band_land_frac:cell_methods = "area: mean (beam-weighted)" ;
        string band_land_frac:coverage_content_type = "referenceInformation" ;
    float band_surf_alt(atrack, xtrack, band) ;
        string band_surf_alt:units = "m" ;
        band_surf_alt:valid_range = -500.f, 10000.f ;
        string band_surf_alt:long_name = "band surface altitude" ;
        string band_surf_alt:standard_name = "surface_altitude" ;
        string band_surf_alt:coordinates = "band_lbl band_lat band_lon" ;
        string band_surf_alt:description = "band-specific mean surface altitude over the fov" ;
        band_surf_alt:_FillValue = 9.96921e+36f ;
        string band_surf_alt:cell_methods = "area: mean (beam-weighted)" ;
        string band_surf_alt:coverage_content_type = "referenceInformation" ;
    ushort band_geoloc_chan(band) ;
        string band_geoloc_chan:units = "1" ;
        band_geoloc_chan:valid_range = 1US, 22US ;
        string band_geoloc_chan:long_name = "band geolocation channel" ;
        string band_geoloc_chan:coordinates = "bad_lbl" ;
        string band_geoloc_chan:description = "Channel used in determining the geolocation
information for each band" ;
        band_geoloc_chan:_FillValue = 65535US ;
        string band_geoloc_chan:coverage_content_type = "referenceInformation" ;
    float antenna_temp(atrack, xtrack, channel) ;
        string antenna_temp:units = "Kelvin" ;
        string antenna_temp:ancillary_variables = "antenna_temp_qc" ;
        antenna_temp:valid_range = 0.f, 400.f ;
        string antenna_temp:long_name = "antenna temperature" ;
        string antenna_temp:standard_name = "brightness_temperature" ;
        string antenna_temp:coordinates = "lon lat" ;
        string antenna_temp:description = "Calibrated scene brightness temperature for each ATMS
channel and beam position. This output is the Rayleigh equivalent temperature and not the Planck blackbody
equivalent temperature" ;
        antenna_temp:_FillValue = 9.96921e+36f ;
        string antenna_temp:coverage_content_type = "physicalMeasurement" ;
```

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```
byte antenna_temp_qc(atrack, xtrack, channel) ;
        antenna_temp_qc:valid_range = 0b, 2b ;
        string antenna_temp_qc:long_name = "antenna_temp QC" ;
        string antenna_temp_qc:standard_name = "brightness_temperature status_flag" ;
        string antenna_temp_qc:coordinates = "lon lat" ;
        string antenna_temp_qc:description = "antenna_temp QC flag" ;
        antenna_temp_qc:_FillValue = -1b ;
        string antenna_temp_qc:coverage_content_type = "qualityInformation" ;
        string antenna_temp_qc:flag_meanings = "Best Good Do_Not_Use" ;
        antenna_temp_qc:flag_values = 0b, 1b, 2b ;
float cold_nedt(channel) ;
        string cold_nedt:units = "Kelvin" ;
        cold_nedt:valid_range = 0.001f, 100.f ;
        string cold_nedt:long_name = "cold NEdT" ;
        string cold_nedt:description = "Noise equivalent delta temperature derived from observations of
cold space" ;
        cold_nedt:_FillValue = 9.96921e+36f ;
        string cold_nedt:coverage_content_type = "qualityInformation" ;
float warm_nedt(channel) ;
        string warm_nedt:units = "Kelvin" ;
        warm_nedt:valid_range = 0.001f, 100.f ;
        string warm_nedt:long_name = "warm NEdT" ;
        string warm_nedt:description = "Noise equivalent delta temperature derived from observations
of the warm calibration target" ;
        warm_nedt:_FillValue = 9.96921e+36f ;
        string warm_nedt:coverage_content_type = "qualityInformation" ;
string band_lbl(band) ;
        string band_lbl:long_name = "Band name" ;
        string band_lbl:standard_name = "sensor_band_identifier" ;
        string band_lbl:description = "List of Microwave bands (K, Ka, V, W, G)" ;
        string band_lbl:coverage_content_type = "auxillaryInformation" ;
ushort channel(channel) ;
        string channel:units = "1" ;
        string channel:long_name = "channel number" ;
        string channel:description = "Number for each channel (1-22)" ;
        channel:_FillValue = 65535US ;
        string channel:coverage_content_type = "auxillaryInformation" ;
string chan_band(channel) ;
        string chan_band:long_name = "channel band" ;
        string chan_band:description = "Name of band for each channel" ;
        string chan_band:coverage_content_type = "auxillaryInformation" ;
char antenna(channel) ;
        string antenna:long_name = "antenna name" ;
        string antenna:description = "Name of antenna for each channel" ;
        antenna:_FillValue = "," ;
        string antenna:coverage_content_type = "auxillaryInformation" ;
float center_freq(channel) ;
        string center_freq:units = "MHz" ;
        string center_freq:long_name = "channel center frequency" ;
        string center_freq:standard_name = "sensor_band_central_radiation_frequency" ;
        string center_freq:description = "Channel center frequency" ;
        center_freq:_FillValue = 9.96921e+36f ;
        string center_freq:coverage_content_type = "auxillaryInformation" ;
float if_offset_1(channel) ;
        string if_offset_1:units = "MHz" ;
```

```
        string if_offset_1:long_name = "first intermediate frequency offset" ;
        string if_offset_1:description = "Offset of first intermediate frequency stage (zero for no mixing)"
;
        if_offset_1:_FillValue = 9.96921e+36f ;
        string if_offset_1:coverage_content_type = "auxillaryInformation" ;
    float if_offset_2(channel) ;
        string if_offset_2:units = "MHz" ;
        string if_offset_2:long_name = "second intermediate frequency offset" ;
        string if_offset_2:description = "Offset of second intermediate frequency stage (zero for no
mixing)" ;
        if_offset_2:_FillValue = 9.96921e+36f ;
        string if_offset_2:coverage_content_type = "auxillaryInformation" ;
    float bandwidth(channel) ;
        string bandwidth:units = "MHz" ;
        string bandwidth:long_name = "total bandwidth" ;
        string bandwidth:description = "bandwidth of sum of 1, 2, or 4 channels" ;
        bandwidth:_FillValue = 9.96921e+36f ;
        string bandwidth:coverage_content_type = "auxillaryInformation" ;
    char polarization(channel) ;
        string polarization:long_name = "Polarization" ;
        string polarization:description = "Nominal polarization: Vertical or Horizontal" ;
        polarization:_FillValue = "," ;
        string polarization:coverage_content_type = "auxillaryInformation" ;
    float beam_width(channel) ;
        string beam_width:units = "degree" ;
        string beam_width:long_name = "Beam width" ;
        string beam_width:description = "Nominal beam width" ;
        beam_width:_FillValue = 9.96921e+36f ;
        string beam_width:coverage_content_type = "auxillaryInformation" ;

group: aux {
  variables:
    int geo_qualflag(atrack, xtrack) ;
        string geo_qualflag:long_name = "geolocation quality" ;
        string geo_qualflag:description = "
            Bit 7 - Failed geolocation on Earth topographic surface (surface_loc)
            Bit 6 - Could not set FOV surface elevations and land water fraction (DEM)
            Bit 5 - Failed geolocation on Earth geoid (geoid_loc)
            Bit 4 - Failed to set solar zenith or azimuth angles (solar_ang)
            Bit 3 - Failed to set spacecraft zenith or azimuth angles (spacecraft_ang)
            Bit 2 - Unused (0)
            Bit 1 (LSB) - Failed geolocation of some bands (band_specific)" ;
        geo_qualflag:_FillValue = -2147483647 ;
        string geo_qualflag:coverage_content_type = "qualityInformation" ;
        string geo_qualflag:flag_meanings = "surface_loc DEM geoid_loc solar_ang spacecraft_ang
band_specific" ;
        geo_qualflag:flag_values = 64, 32, 16, 8, 4, 1 ;
    int cal_qualflag(atrack, channel) ;
        string cal_qualflag:long_name = "calibration quality flags" ;
        string cal_qualflag:coordinates = "subsat_lon subsat_lat" ;
        string cal_qualflag:description = "(Bit 32 is most significant.  It is not used because it can cause
confusion when this flag is used as a signed or unsigned integer.)
            Bit 7 : No usable calibration.  Scan is not calibrated. (cal_failed)\nBit 6 : Calibration values
used from different scan. (cal_from_diff_scan)
```

Bit 5: Insufficient valid shelf temperature values to use in a scan calibration. Fall-back constant shelf temperatures are used. (shelf_temp_bad)

Bit 4: Excess noise (noise)

Bit 3: Telemetry out of limits (telem)

Bit 2: Spectral quality is poor (spectral)

Bit 1 (LSB): reserved (0)" ;

cal_qualflag:_FillValue = -2147483647 ;

string cal_qualflag:coverage_content_type = "qualityInformation" ;

string cal_qualflag:flag_meanings = "spectral telem noise shelf_temp_bad cal_from_diff_scan cal_failed" ;

cal_qualflag:flag_values = 2, 4, 8, 16, 32, 64 ;

int cal_space_qualflag(atrack, channel) ;

string cal_space_qualflag:long_name = "space view calibration quality flags" ;

string cal_space_qualflag:coordinates = "subsat_lon subsat_lat" ;

string cal_space_qualflag:description = "(Bit 32 is most significant. It is not used because it can cause confusion when this flag is used as a signed or unsigned integer.)

Bit 14 : Insufficient valid space (cold calibration) observation counts to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (cold_cal_bad)

Bit 13: Insufficient effective space temperature values to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (space_temp_bad)

Bit 12: This scan's space view #1 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv1_bad)

Bit 11: This scan's space view #2 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv2_bad)

Bit 10 : This scan's space view #3 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv3_bad)

Bit 9 : This scan's space view #4 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv4_bad)

Bit 8: Missing moon angle for this scan's space view #1. Lunar intrusion status is unknown. (sv1_moon_unknown)

Bit 7: Missing moon angle for this scan's space view #2. Lunar intrusion status is unknown. (sv2_moon_unknown)

Bit 6: Missing moon angle for this scan's space view #3. Lunar intrusion status is unknown. (sv3_moon_unknown)

Bit 5: Missing moon angle for this scan's space view #4. Lunar intrusion status is unknown. (sv4_moon_unknown)

Bits 1-4: reserved (0)" ;

cal_space_qualflag:_FillValue = -2147483647 ;

string cal_space_qualflag:coverage_content_type = "qualityInformation" ;

string cal_space_qualflag:flag_meanings = "sv4_moon_unknown sv3_moon_unknown sv2_moon_unknown sv1_moon_unknown sv4_bad sv3_bad sv2_bad sv1_bad space_temp_bad cold_cal_bad" ;

cal_space_qualflag:flag_values = 16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 8192 ;

int cal_blackbody_qualflag(atrack, channel) ;

string cal_blackbody_qualflag:long_name = "blackbody calibration quality flags" ;

string cal_blackbody_qualflag:coordinates = "subsat_lon subsat_lat" ;

string cal_blackbody_qualflag:description = "(Bit 32 is most significant. It is not used because it can cause confusion when this flag is used as a signed or unsigned integer.)

Bit 3: Insufficient valid black body (warm calibration) observation counts to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (warm_cal_bad)

Bit 2: Insufficient valid black body temperature readings to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (bb_temp_bad)

              Bit 1 (LSB): This scan's black body view not used. A scan-specific calibration may still be calculated using black body views from neighboring scans. (bb_bad)" ;
        cal_blackbody_qualflag:_FillValue = -2147483647 ;
        string cal_blackbody_qualflag:coverage_content_type = "qualityInformation" ;
        string cal_blackbody_qualflag:flag_meanings = "bb_bad bb_temp_bad warm_cal_bad" ;
        cal_blackbody_qualflag:flag_values = 1, 2, 4 ;
    float offset(atrack, channel) ;
        string offset:units = "Kelvin" ;
        string offset:long_name = "calibration offset" ;
        string offset:coordinates = "subsat_lon subsat_lat" ;
        string offset:description = "Offset used in calibrating earth scene brightness temps." ;
        offset:_FillValue = 9.96921e+36f ;
        string offset:coverage_content_type = "auxillaryInformation" ;
    float gain(atrack, channel) ;
        string gain:units = "Count/Kelvin" ;
        string gain:long_name = "calibration gain" ;
        string gain:coordinates = "subsat_lon subsat_lat" ;
        string gain:description = "Gain factor used in calibrating earth scene brightness temps." ;
        gain:_FillValue = 9.96921e+36f ;
        string gain:coverage_content_type = "auxillaryInformation" ;
    float nonlin(atrack, xtrack, channel) ;
        string nonlin:units = "Kelvin" ;
        nonlin:valid_range = 0.f, 400.f ;
        string nonlin:long_name = "nonlinearity correction" ;
        string nonlin:coordinates = "lon lat" ;
        string nonlin:description = "Nonlinearity correction used in calibrating earth scene brightness temps." ;
        nonlin:_FillValue = 9.96921e+36f ;
        string nonlin:coverage_content_type = "auxillaryInformation" ;
    float cold_temp(atrack, channel) ;
        string cold_temp:units = "Kelvin" ;
        string cold_temp:long_name = "cold space temperature" ;
        string cold_temp:coordinates = "subsat_lon subsat_lat" ;
        string cold_temp:description = "Effective temperature of cold calibration view (space) (Tcc)" ;
        cold_temp:_FillValue = 9.96921e+36f ;
        string cold_temp:coverage_content_type = "auxillaryInformation" ;
    float warm_temp(atrack, channel) ;
        string warm_temp:units = "Kelvin" ;
        string warm_temp:long_name = "warm calibration temperature" ;
        string warm_temp:coordinates = "subsat_lon subsat_lat" ;
        string warm_temp:description = "Effective temperature of warm calibration view (black body) (Twc)" ;
        warm_temp:_FillValue = 9.96921e+36f ;
        string warm_temp:coverage_content_type = "auxillaryInformation" ;
 } // group aux
}

Appendix D: JPSS-1/NOAA-20 CDL File Definition

```
netcdf SNDR.J1.ATMS.20190101T2354.m06.g240.L1B.std.v02_11.G.190102100346 {
dimensions:
        spatial = 3 ;           // directions: x, y, z
        fov_poly = 8;           // lat/lon points defining the ploygon bounding an fov
                                        (anticlockwise as viewed from above)
        utc_tuple = 8 ;         // parts of UTC time
        attitude = 3 ;          // roll, pitch, yaw
        atrack = 135 ;          // along-track spatial dimension
        xtrack = 96 ;           // cross-track spatial dimension
        channel = 22 ;          // channel number
        band = 5 ;              // Microwave bands
        spacextrack = 4 ;       // space view

// global attributes:
                string :keywords = "EARTH SCIENCE > SPECTRAL/ENGINEERING > MICROWAVE > ANTENNA
TEMPERATURE" ;
                string :Conventions = "CF-1.6, ACDD-1.3" ;
                string :source = "ATMS instrument telemetry" ;
                string :processing_level = "1B" ;
                string :product_name_type_id = "L1B" ;
                string :comment = "" ;
                string :acknowledgment = "Support for this research was provided by NASA." ;
                string :standard_name_vocabulary = "CF Standard Name Table v28" ;
                string :project = "Sounder SIPS" ;
                string :product_name_project = "SNDR" ;
                string :geospatial_bounds_crs = "EPSG:4326" ;
                string :time_coverage_duration = "P0000-00-00T00:06:00" ;
                string :product_name_duration = "m06" ;
                string :creator_type = "institution" ;
                string :keywords_vocabulary = "GCMD:GCMD Keywords" ;
                string :platform = "JPSS-1 > Joint Polar Satellite System - 1" ;
                string :platform_vocabulary = "GCMD:GCMD Keywords" ;
                string :instrument = "ATMS > Advanced Technology Microwave Sounder" ;
                string :instrument_vocabulary = "GCMD:GCMD Keywords" ;
                string :product_name_instr = "ATMS" ;
                string :product_name_extension = "nc" ;
                string :featureType = "point" ;
                string :data_structure = "swath" ;
                string :cdm_data_type = "Swath" ;
                string :format_version = "v02.00.23" ;
                string :title = "JPSS-1 ATMS Level-1B" ;
                string :summary = "The Level-1B ATMS product includes data from the ATMS instrument for
one six-minute interval.  Data is geolocated and calibrated to antenna temperature." ;
                string :shortname = "SNDRJ1ATMSL1B" ;
                string :product_group = "l1b_atms" ;
                string :references = "ATMS ATBD is in review.  It will be published at
http://eospso.gsfc.nasa.gov/content/algorithm-theoretical-basis-documents" ;
```

string :contributor_name = "Jet Propulsion Laboratory: Bjorn Lambrigtsen" ;
string :contributor_role = "ATMS Scientist" ;
string :history = "Created on 2019-01-02T06:34:00Z by L1A ATMS PGE at Sounder SIPS: GES DISC, v02.11.02; Created on 2019-01-02T10:03:46Z by Level 1B ATMS PGE at Sounder SIPS: GES DISC, version v02_11" ;
string :license = "Freely Distributed" ;
string :date_created = "2019-01-02T10:03:46Z" ;
string :creator_name = "Sounder SIPS: GES DISC" ;
string :creator_email = "gsfc-help-disc@lists.nasa.gov" ;
string :creator_url = "http://disc.sci.gsfc.nasa.gov/" ;
string :institution = "Goddard Space Flight Center - National Aeronautics and Space Administration" ;
string :publisher_name = "Goddard Earth Science Data and Information Services Center" ;
string :publisher_email = "gsfc-help-disc@lists.nasa.gov" ;
string :publisher_url = "http://disc.sci.gsfc.nasa.gov/" ;
string :geospatial_bounds = "POLYGON ((49.69 173.60, 55.34 -149.85, 75.92 -146.42, 65.55 146.45, 49.69 173.60))" ;
:geospatial_lat_min = 49.69735f ;
:geospatial_lat_max = 75.92578f ;
:geospatial_lon_min = 173.604f ;
:geospatial_lon_max = -149.854f ;
string :time_coverage_start = "2019-01-01T23:54:00Z" ;
string :time_of_first_valid_obs = "2019-01-01T23:54:00Z" ;
string :time_coverage_mid = "2019-01-01T23:57:00Z" ;
string :time_coverage_end = "2019-01-02T00:00:00Z" ;
string :time_of_last_valid_obs = "2019-01-01T23:59:59Z" ;
string :creator_institution = "Goddard Space Flight Center - National Aeronautics and Space Administration" ;
string :product_version = "v02.11.02" ;
string :product_name_platform = "J1" ;
string :product_name = "SNDR.J1.ATMS.20190101T2354.m06.g240.L1B.std.v02_11.G.190102100346.nc" ;
string :product_name_variant = "std" ;
string :product_name_version = "v02_11" ;
string :product_name_producer = "G" ;
string :product_name_timestamp = "190102100346" ;
:granule_number = 240US ;
string :product_name_granule_number = "g240" ;
string :gran_id = "20190101T2354" ;
:geospatial_lat_mid = 62.81157f ;
:geospatial_lon_mid = -168.125f ;
string :id = "10.5067/VP66V3OTXOPY" ;
string :naming_authority = "http://dx.doi.org/" ;
string :identifier_product_doi = "10.5067/VP66V3OTXOPY" ;
string :identifier_product_doi_authority = "http://dx.doi.org/" ;
string :algorithm_version = "2017-08 IDPS emulation" ;
string :production_host = "Linux gs6102dsc-ac16.gesdisc.eosdis.nasa.gov 2.6.32-754.9.1.el6.x86_64 #1 SMP Thu Dec 6 08:02:15 UTC 2018 x86_64 x86_64 x86_64 GNU/Linux" ;
string :input_file_names = "SNDRJ1ATMSL1A.A2019001.2348.2.2019001231348.hdf; SNDRJ1ATMSL1A.A2019001.2354.2.2019002013350.hdf; SNDRJ1ATMSL1A.A2019002.0000.2.2019002013350.hdf; SNDR.J1.L1bMw.apf.181010000000.xml; SNDR.J1.L1bMw.template.180523000000.nc" ;
string :input_file_types = "ATMS_L1A; ATMS_L1A; ATMS_L1A; ATMS_L1B_AlgParam; ATMS_L1B_Template" ;
string :input_file_dates = "2019-01-01; 2019-01-01; 2019-01-02; N/A; N/A" ;

```
        string :orbitDirection = "Ascending" ;
        string :day_night_flag = "Both" ;
        string :AutomaticQualityFlag = "Passed" ;
        :qa_pct_data_missing = 0.f ;
        :qa_pct_data_geo = 100.f ;
        :qa_pct_data_sci_mode = 100.f ;
        string :qa_no_data = "FALSE" ;
        string :metadata_link = "http://disc.sci.gsfc.nasa.gov/" ;


variables:
    string obs_id(atrack, xtrack) ;
        string obs_id:long_name = "earth view observation id" ;
        string obs_id:description = "unique earth view observation identifier:
yyyymmddThhmm.aa[a]Exx .  Includes gran_id plus two- or three-digit along-track index (01-45 or 001-135)
and 2-digit cross-track index (01-96)." ;
        string obs_id:coverage_content_type = "referenceInformation" ;
    ubyte instrument_state(atrack, xtrack) ;
        string instrument_state:long_name = "instrument state" ;
        string instrument_state:coordinates = "lon lat" ;
        string instrument_state:description = "instrument/data state: 0/'Process' - Data is usable for
science; 1/'Special' - Observations are valid but instrument is not configured for science data (ex: stare
mode); 2/'Erroneous' - Data is not usable (ex: checksum error); 3/'Missing' - No data was received." ;
        instrument_state:_FillValue = 255UB ;
        string instrument_state:coverage_content_type = "qualityInformation" ;
        string instrument_state:flag_meanings = "Process Special Erroneous Missing" ;
        instrument_state:flag_values = 0UB, 1UB, 2UB, 3UB ;
    double obs_time_tai93(atrack, xtrack) ;
        string obs_time_tai93:units = "seconds since 1993-01-01 00:00" ;
        obs_time_tai93:valid_range = -2934835217., 3376598410. ;
        string obs_time_tai93:long_name = "earth view FOV midtime" ;
        string obs_time_tai93:standard_name = "time" ;
        string obs_time_tai93:description = "earth view observation midtime for each FOV" ;
        obs_time_tai93:_FillValue = 9.96920996838687e+36 ;
        string obs_time_tai93:coverage_content_type = "referenceInformation" ;
    ushort obs_time_utc(atrack, xtrack, utc_tuple) ;
        string obs_time_utc:long_name = "earth view UTC FOV time" ;
        string obs_time_utc:coordinates = "utc_tuple_lbl" ;
        string obs_time_utc:description = "UTC earth view observation time as an array of integers: year,
month, day, hour, minute, second, millisec, microsec" ;
        obs_time_utc:_FillValue = 65535US ;
        string obs_time_utc:coverage_content_type = "referenceInformation" ;
    float lat(atrack, xtrack) ;
        string lat:units = "degrees_north" ;
        lat:valid_range = -90.f, 90.f ;
        string lat:long_name = "latitude" ;
        string lat:standard_name = "latitude" ;
        string lat:description = "latitude of FOV center" ;
        lat:_FillValue = 9.96921e+36f ;
        string lat:coverage_content_type = "referenceInformation" ;
        string lat:bounds = "lat_bnds" ;
    float lat_geoid(atrack, xtrack) ;
        string lat_geoid:units = "degrees_north" ;
        lat_geoid:valid_range = -90.f, 90.f ;
        string lat_geoid:long_name = "latitude" ;
```

```
        string lat_geoid:standard_name = "latitude" ;
        string lat_geoid:description = "latitude of FOV center on the geoid (without terrain correction)" ;
        lat_geoid:_FillValue = 9.96921e+36f ;
        string lat_geoid:coverage_content_type = "referenceInformation" ;
float lon(atrack, xtrack) ;
        string lon:units = "degrees_east" ;
        lon:valid_range = -180.f, 180.f ;
        string lon:long_name = "longitude" ;
        string lon:standard_name = "longitude" ;
        string lon:description = "longitude of FOV center" ;
        lon:_FillValue = 9.96921e+36f ;
        string lon:coverage_content_type = "referenceInformation" ;
        string lon:bounds = "lon_bnds" ;
float lon_geoid(atrack, xtrack) ;
        string lon_geoid:units = "degrees_east" ;
        lon_geoid:valid_range = -180.f, 180.f ;
        string lon_geoid:long_name = "longitude" ;
        string lon_geoid:standard_name = "longitude" ;
        string lon_geoid:description = "longitude of FOV center on the geoid (without terrain
correction)" ;
        lon_geoid:_FillValue = 9.96921e+36f ;
        string lon_geoid:coverage_content_type = "referenceInformation" ;
float lat_bnds(atrack, xtrack, fov_poly) ;
        string lat_bnds:units = "degrees_north" ;
        lat_bnds:valid_range = -90.f, 90.f ;
        string lat_bnds:long_name = "FOV boundary latitudes" ;
        string lat_bnds:description = "latitudes of points forming a polygon around the perimeter of the
FOV" ;
        lat_bnds:_FillValue = 9.96921e+36f ;
        string lat_bnds:coverage_content_type = "referenceInformation" ;
float lon_bnds(atrack, xtrack, fov_poly) ;
        string lon_bnds:units = "degrees_east" ;
        lon_bnds:valid_range = -180.f, 180.f ;
        string lon_bnds:long_name = "FOV boundary longitudes" ;
        string lon_bnds:description = "longitudes of points forming a polygon around the perimeter of
the FOV" ;
        lon_bnds:_FillValue = 9.96921e+36f ;
        string lon_bnds:coverage_content_type = "referenceInformation" ;
float land_frac(atrack, xtrack) ;
        string land_frac:units = "1" ;
        land_frac:valid_range = 0.f, 1.f ;
        string land_frac:long_name = "land fraction" ;
        string land_frac:standard_name = "land_area_fraction" ;
        string land_frac:coordinates = "lon lat" ;
        string land_frac:description = "land fraction over the FOV" ;
        land_frac:_FillValue = 9.96921e+36f ;
        string land_frac:coverage_content_type = "referenceInformation" ;
        string land_frac:cell_methods = "area: mean (beam-weighted)" ;
float surf_alt(atrack, xtrack) ;
        string surf_alt:units = "m" ;
        string surf_alt:ancillary_variables = "surf_alt_sdev" ;
        surf_alt:valid_range = -500.f, 10000.f ;
        string surf_alt:long_name = "surface altitude" ;
        string surf_alt:standard_name = "surface_altitude" ;
        string surf_alt:coordinates = "lon lat" ;
```

```
            string surf_alt:description = "mean surface altitude wrt  earth model over the FOV" ;
            surf_alt:_FillValue = 9.96921e+36f ;
            string surf_alt:coverage_content_type = "referenceInformation" ;
            string surf_alt:cell_methods = "area: mean (beam-weighted)" ;
    float surf_alt_sdev(atrack, xtrack) ;
            string surf_alt_sdev:units = "m" ;
            surf_alt_sdev:valid_range = 0.f, 10000.f ;
            string surf_alt_sdev:long_name = "surface altitude standard deviation" ;
            string surf_alt_sdev:coordinates = "lon lat" ;
            string surf_alt_sdev:description = "standard deviation of surface altitude within the FOV" ;
            surf_alt_sdev:_FillValue = 9.96921e+36f ;
            string surf_alt_sdev:coverage_content_type = "qualityInformation" ;
            string surf_alt_sdev:cell_methods = "area: standard_deviation (beam-weighted)" ;
    float sun_glint_lat(atrack) ;
            string sun_glint_lat:units = "degrees_north" ;
            sun_glint_lat:valid_range = -90.f, 90.f ;
            string sun_glint_lat:long_name = "sun glint latitude" ;
            string sun_glint_lat:standard_name = "latitude" ;
            string sun_glint_lat:coordinates = "subsat_lon subsat_lat" ;
            string sun_glint_lat:description = "sun glint spot latitude at scan_mid_time.  Fill for night
observations." ;
            sun_glint_lat:_FillValue = 9.96921e+36f ;
            string sun_glint_lat:coverage_content_type = "referenceInformation" ;
    float sun_glint_lon(atrack) ;
            string sun_glint_lon:units = "degrees_east" ;
            sun_glint_lon:valid_range = -180.f, 180.f ;
            string sun_glint_lon:long_name = "sun glint longitude" ;
            string sun_glint_lon:standard_name = "longitude" ;
            string sun_glint_lon:coordinates = "subsat_lon subsat_lat" ;
            string sun_glint_lon:description = "sun glint spot longitude at scan_mid_time.  Fill for night
observations." ;
            sun_glint_lon:_FillValue = 9.96921e+36f ;
            string sun_glint_lon:coverage_content_type = "referenceInformation" ;
    float sol_zen(atrack, xtrack) ;
            string sol_zen:units = "degree" ;
            sol_zen:valid_range = 0.f, 180.f ;
            string sol_zen:long_name = "solar zenith angle" ;
            string sol_zen:standard_name = "solar_zenith_angle" ;
            string sol_zen:coordinates = "lon lat" ;
            string sol_zen:description = "solar zenith angle at the center of the spot" ;
            sol_zen:_FillValue = 9.96921e+36f ;
            string sol_zen:coverage_content_type = "referenceInformation" ;
    float sol_azi(atrack, xtrack) ;
            string sol_azi:units = "degree" ;
            sol_azi:valid_range = 0.f, 360.f ;
            string sol_azi:long_name = "solar azimuth angle" ;
            string sol_azi:standard_name = "solar_azimuth_angle" ;
            string sol_azi:coordinates = "lon lat" ;
            string sol_azi:description = "solar azimuth angle at the center of the spot (clockwise from
North)" ;
            sol_azi:_FillValue = 9.96921e+36f ;
            string sol_azi:coverage_content_type = "referenceInformation" ;
    float sun_glint_dist(atrack, xtrack) ;
            string sun_glint_dist:units = "m" ;
            sun_glint_dist:valid_range = 0.f, 3.e+07f ;
```

```
          string sun_glint_dist:long_name = "sun glint distance" ;
          string sun_glint_dist:coordinates = "lon lat" ;
          string sun_glint_dist:description = "distance of sun glint spot to the center of the spot.  Fill for
night observations." ;
          sun_glint_dist:_FillValue = 9.96921e+36f ;
          string sun_glint_dist:coverage_content_type = "referenceInformation" ;
     float view_ang(atrack, xtrack) ;
          string view_ang:units = "degree" ;
          view_ang:valid_range = 0.f, 180.f ;
          string view_ang:long_name = "view angle" ;
          string view_ang:standard_name = "sensor_view_angle" ;
          string view_ang:coordinates = "lon lat" ;
          string view_ang:description = "off nadir pointing angle" ;
          view_ang:_FillValue = 9.96921e+36f ;
          string view_ang:coverage_content_type = "referenceInformation" ;
     float sat_zen(atrack, xtrack) ;
          string sat_zen:units = "degree" ;
          sat_zen:valid_range = 0.f, 180.f ;
          string sat_zen:long_name = "satellite zenith angle" ;
          string sat_zen:standard_name = "sensor_zenith_angle" ;
          string sat_zen:coordinates = "lon lat" ;
          string sat_zen:description = "satellite zenith angle at the center of the spot" ;
          sat_zen:_FillValue = 9.96921e+36f ;
          string sat_zen:coverage_content_type = "referenceInformation" ;
     float sat_azi(atrack, xtrack) ;
          string sat_azi:units = "degree" ;
          sat_azi:valid_range = 0.f, 360.f ;
          string sat_azi:long_name = "satellite azimuth angle" ;
          string sat_azi:standard_name = "sensor_azimuth_angle" ;
          string sat_azi:coordinates = "lon lat" ;
          string sat_azi:description = "satellite azimuth angle at the center of the spot (clockwise from
North)" ;
          sat_azi:_FillValue = 9.96921e+36f ;
          string sat_azi:coverage_content_type = "referenceInformation" ;
     float sat_range(atrack, xtrack) ;
          string sat_range:units = "m" ;
          sat_range:valid_range = 100000.f, 1.e+07f ;
          string sat_range:long_name = "satellite range" ;
          string sat_range:coordinates = "lon lat" ;
          string sat_range:description = "line of sight distance between satellite and spot center" ;
          sat_range:_FillValue = 9.96921e+36f ;
          string sat_range:coverage_content_type = "referenceInformation" ;
     ubyte asc_flag(atrack) ;
          asc_flag:valid_range = 0UB, 1UB ;
          string asc_flag:long_name = "ascending orbit flag" ;
          string asc_flag:coordinates = "subsat_lon subsat_lat" ;
          string asc_flag:description = "ascending orbit flag: 1 if ascending, 0 descending" ;
          asc_flag:_FillValue = 255UB ;
          string asc_flag:coverage_content_type = "referenceInformation" ;
          string asc_flag:flag_meanings = "descending ascending" ;
          asc_flag:flag_values = 0UB, 1UB ;
     float subsat_lat(atrack) ;
          string subsat_lat:units = "degrees_north" ;
          subsat_lat:valid_range = -90.f, 90.f ;
          string subsat_lat:long_name = "sub-satellite latitude" ;
```

```
        string subsat_lat:standard_name = "latitude" ;
        string subsat_lat:description = "sub-satellite latitude at scan_mid_time" ;
        subsat_lat:_FillValue = 9.96921e+36f ;
        string subsat_lat:coverage_content_type = "referenceInformation" ;
float subsat_lon(atrack) ;
        string subsat_lon:units = "degrees_east" ;
        subsat_lon:valid_range = -180.f, 180.f ;
        string subsat_lon:long_name = "sub-satellite longitude" ;
        string subsat_lon:standard_name = "longitude" ;
        string subsat_lon:description = "sub-satellite longitude at scan_mid_time" ;
        subsat_lon:_FillValue = 9.96921e+36f ;
        string subsat_lon:coverage_content_type = "referenceInformation" ;
double scan_mid_time(atrack) ;
        string scan_mid_time:units = "seconds since 1993-01-01 00:00" ;
        scan_mid_time:valid_range = -2934835217., 3376598410. ;
        string scan_mid_time:long_name = "midscan TAI93" ;
        string scan_mid_time:standard_name = "time" ;
        string scan_mid_time:coordinates = "subsat_lon subsat_lat" ;
        string scan_mid_time:description = "TAI93 at  middle of earth scene scans" ;
        scan_mid_time:_FillValue = 9.96920996838687e+36 ;
        string scan_mid_time:coverage_content_type = "referenceInformation" ;
float sat_alt(atrack) ;
        string sat_alt:units = "m" ;
        sat_alt:valid_range = 100000.f, 1000000.f ;
        string sat_alt:long_name = "satellite altitude" ;
        string sat_alt:standard_name = "altitude" ;
        string sat_alt:coordinates = "subsat_lon subsat_lat" ;
        string sat_alt:description = "satellite altitude with respect to earth model at scan_mid_time" ;
        sat_alt:_FillValue = 9.96921e+36f ;
        string sat_alt:coverage_content_type = "referenceInformation" ;
float sat_pos(atrack, spatial) ;
        string sat_pos:units = "m" ;
        string sat_pos:long_name = "satellite position" ;
        string sat_pos:coordinates = "subsat_lon subsat_lat spatial_lbl" ;
        string sat_pos:description = "satellite ECR position at scan_mid_time" ;
        sat_pos:_FillValue = 9.96921e+36f ;
        string sat_pos:coverage_content_type = "referenceInformation" ;
float sat_vel(atrack, spatial) ;
        string sat_vel:units = "m s-1" ;
        string sat_vel:long_name = "satellite velocity" ;
        string sat_vel:coordinates = "subsat_lon subsat_lat spatial_lbl" ;
        string sat_vel:description = "satellite ECR velocity at scan_mid_time" ;
        sat_vel:_FillValue = 9.96921e+36f ;
        string sat_vel:coverage_content_type = "referenceInformation" ;
float sat_att(atrack, attitude) ;
        string sat_att:units = "degree" ;
        sat_att:valid_range = -180.f, 180.f ;
        string sat_att:long_name = "satellite attitude" ;
        string sat_att:coordinates = "subsat_lon subsat_lat angular_lbl" ;
        string sat_att:description = "satellite attitude at scan_mid_time.  An orthogonal triad.  First
element is angle about the +x (roll) ORB axis.  +x axis is positively oriented in the direction of orbital flight.
Second element is 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.  Third element is 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." ;
```

```
        sat_att:_FillValue = 9.96921e+36f ;
        string sat_att:coverage_content_type = "referenceInformation" ;
float moon_ang(atrack, spacextrack) ;
        string moon_ang:units = "degree" ;
        moon_ang:valid_range = 0.f, 180.f ;
        string moon_ang:long_name = "moon angle" ;
        string moon_ang:coordinates = "subsat_lon subsat_lat" ;
        string moon_ang:description = "angle between moon and FOV center for space view" ;
        moon_ang:_FillValue = 9.96921e+36f ;
        string moon_ang:coverage_content_type = "referenceInformation" ;
float local_solar_time(atrack, xtrack) ;
        string local_solar_time:units = "hours" ;
        local_solar_time:valid_range = 0.f, 24.f ;
        string local_solar_time:long_name = "local apparent solar time" ;
        string local_solar_time:coordinates = "lon lat" ;
        string local_solar_time:description = "local apparent solar time in hours from midnight" ;
        local_solar_time:_FillValue = 9.96921e+36f ;
        string local_solar_time:coverage_content_type = "referenceInformation" ;
float mean_anom_wrt_equat(atrack) ;
        string mean_anom_wrt_equat:units = "degree" ;
        mean_anom_wrt_equat:valid_range = 0.f, 360.f ;
        string mean_anom_wrt_equat:long_name = "mean anomaly with respect to the equator" ;
        string mean_anom_wrt_equat:coordinates = "subsat_lon subsat_lat" ;
        string mean_anom_wrt_equat:description = "spacecraft mean anomaly measured with respect to
the ascending node" ;
        mean_anom_wrt_equat:_FillValue = 9.96921e+36f ;
        string mean_anom_wrt_equat:coverage_content_type = "referenceInformation" ;
float sat_sol_zen(atrack) ;
        string sat_sol_zen:units = "degree" ;
        sat_sol_zen:valid_range = 0.f, 180.f ;
        string sat_sol_zen:long_name = "satellite solar zenith" ;
        string sat_sol_zen:coordinates = "subsat_lon subsat_lat" ;
        string sat_sol_zen:description = "solar zenith angle at the satellite" ;
        sat_sol_zen:_FillValue = 9.96921e+36f ;
        string sat_sol_zen:coverage_content_type = "referenceInformation" ;
float sat_sol_azi(atrack) ;
        string sat_sol_azi:units = "degree" ;
        sat_sol_azi:valid_range = 0.f, 360.f ;
        string sat_sol_azi:long_name = "satellite solar azimuth" ;
        string sat_sol_azi:coordinates = "subsat_lon subsat_lat" ;
        string sat_sol_azi:description = "solar azimuth angle at the satellite (clockwise from North)" ;
        sat_sol_azi:_FillValue = 9.96921e+36f ;
        string sat_sol_azi:coverage_content_type = "referenceInformation" ;
float asc_node_lon ;
        string asc_node_lon:units = "degrees_east" ;
        asc_node_lon:valid_range = -180.f, 180.f ;
        string asc_node_lon:long_name = "ascending node" ;
        string asc_node_lon:description = "Longitude of the last ascending node of spacecraft orbit
before time_coverage_end." ;
        asc_node_lon:_FillValue = 9.96921e+36f ;
        string asc_node_lon:coverage_content_type = "referenceInformation" ;
double asc_node_tai93 ;
        string asc_node_tai93:units = "seconds since 1993-01-01 00:00" ;
        asc_node_tai93:valid_range = -2934835217., 3376598410. ;
        string asc_node_tai93:long_name = "ascending node time" ;
```

```
        string asc_node_tai93:description = "TAI93 time of the last ascending node of spacecraft orbit
before time_coverage_end." ;
        asc_node_tai93:_FillValue = 9.96920996838687e+36 ;
        string asc_node_tai93:coverage_content_type = "referenceInformation" ;
float asc_node_local_solar_time ;
        string asc_node_local_solar_time:units = "hours" ;
        asc_node_local_solar_time:valid_range = 0.f, 24.f ;
        string asc_node_local_solar_time:long_name = "local apparent solar time at the ascending node" ;
        string asc_node_local_solar_time:description = "local apparent solar time at the last ascending
node before time_coverage_end in hours from midnight" ;
        asc_node_local_solar_time:_FillValue = 9.96921e+36f ;
        string asc_node_local_solar_time:coverage_content_type = "referenceInformation" ;
float solar_beta_angle ;
        string solar_beta_angle:units = "degree" ;
        solar_beta_angle:valid_range = -90.f, 90.f ;
        string solar_beta_angle:long_name = "beta angle" ;
        string solar_beta_angle:description = "Beta angle for the spacecraft orbit, determining the
percentage of the orbit that the spacecraft is in direct sunlight." ;
        solar_beta_angle:_FillValue = 9.96921e+36f ;
        string solar_beta_angle:coverage_content_type = "referenceInformation" ;
string attitude_lbl(attitude) ;
        string attitude_lbl:long_name = "rotational direction" ;
        string attitude_lbl:description = "list of rotational directions (roll, pitch, yaw)" ;
        string attitude_lbl:coverage_content_type = "auxiliaryInformation" ;
string spatial_lbl(spatial) ;
        string spatial_lbl:long_name = "spatial direction" ;
        string spatial_lbl:description = "list of spatial directions (X, Y, Z)" ;
        string spatial_lbl:coverage_content_type = "auxiliaryInformation" ;
string utc_tuple_lbl(utc_tuple) ;
        string utc_tuple_lbl:long_name = "UTC date/time parts" ;
        string utc_tuple_lbl:description = "names of the elements of UTC when it is expressed as an array
of integers year,month,day,hour,minute,second,millisecond,microsecond" ;
        string utc_tuple_lbl:coverage_content_type = "auxiliaryInformation" ;
float band_lat(atrack, xtrack, band) ;
        string band_lat:units = "degrees_north" ;
        band_lat:valid_range = -90.f, 90.f ;
        string band_lat:long_name = "band latitude" ;
        string band_lat:standard_name = "latitude" ;
        string band_lat:description = "band-specific fov center latitude" ;
        band_lat:_FillValue = 9.96921e+36f ;
        string band_lat:coverage_content_type = "referenceInformation" ;
        string band_lat:bounds = "band_lat_bnds" ;
float band_lon(atrack, xtrack, band) ;
        string band_lon:units = "degrees_east" ;
        band_lon:valid_range = -180.f, 180.f ;
        string band_lon:long_name = "band longitude" ;
        string band_lon:standard_name = "longitude" ;
        string band_lon:description = "band-specific fov center longitude" ;
        band_lon:_FillValue = 9.96921e+36f ;
        string band_lon:coverage_content_type = "referenceInformation" ;
        string band_lon:bounds = "band_lon_bnds" ;
float band_lat_bnds(atrack, xtrack, band, fov_poly) ;
        string band_lat_bnds:units = "degrees_north" ;
        band_lat_bnds:valid_range = -90.f, 90.f ;
        string band_lat_bnds:long_name = "band fov boundary latitudes" ;
```

string band_lat_bnds:description = "latitudes of points forming a polygon around the perimeter of the band-specific fov" ;
            band_lat_bnds:_FillValue = 9.96921e+36f ;
            string band_lat_bnds:coverage_content_type = "referenceInformation" ;
      float band_lon_bnds(atrack, xtrack, band, fov_poly) ;
            string band_lon_bnds:units = "degrees_east" ;
            band_lon_bnds:valid_range = -180.f, 180.f ;
            string band_lon_bnds:long_name = "band fov boundary longitudes" ;
            string band_lon_bnds:description = "longitudes of points forming a polygon around the perimeter of the band-specific fov" ;
            band_lon_bnds:_FillValue = 9.96921e+36f ;
            string band_lon_bnds:coverage_content_type = "referenceInformation" ;
      float band_land_frac(atrack, xtrack, band) ;
            string band_land_frac:units = "1" ;
            band_land_frac:valid_range = 0.f, 1.f ;
            string band_land_frac:long_name = "band land fraction" ;
            string band_land_frac:standard_name = "land_area_fraction" ;
            string band_land_frac:coordinates = "band_lbl band_lat band_lon" ;
            string band_land_frac:description = "band-specific land fraction over the fov" ;
            band_land_frac:_FillValue = 9.96921e+36f ;
            string band_land_frac:cell_methods = "area: mean (beam-weighted)" ;
            string band_land_frac:coverage_content_type = "referenceInformation" ;
      float band_surf_alt(atrack, xtrack, band) ;
            string band_surf_alt:units = "m" ;
            band_surf_alt:valid_range = -500.f, 10000.f ;
            string band_surf_alt:long_name = "band surface altitude" ;
            string band_surf_alt:standard_name = "surface_altitude" ;
            string band_surf_alt:coordinates = "band_lbl band_lat band_lon" ;
            string band_surf_alt:description = "band-specific mean surface altitude over the fov" ;
            band_surf_alt:_FillValue = 9.96921e+36f ;
            string band_surf_alt:cell_methods = "area: mean (beam-weighted)" ;
            string band_surf_alt:coverage_content_type = "referenceInformation" ;
      ushort band_geoloc_chan(band) ;
            string band_geoloc_chan:units = "1" ;
            band_geoloc_chan:valid_range = 1US, 22US ;
            string band_geoloc_chan:long_name = "band geolocation channel" ;
            string band_geoloc_chan:coordinates = "bad_lbl" ;
            string band_geoloc_chan:description = "Channel used in determining the geolocation information for each band" ;
            band_geoloc_chan:_FillValue = 65535US ;
            string band_geoloc_chan:coverage_content_type = "referenceInformation" ;
      float antenna_temp(atrack, xtrack, channel) ;
            string antenna_temp:units = "Kelvin" ;
            string antenna_temp:ancillary_variables = "antenna_temp_qc" ;
            antenna_temp:valid_range = 0.f, 400.f ;
            string antenna_temp:long_name = "antenna temperature" ;
            string antenna_temp:standard_name = "brightness_temperature" ;
            string antenna_temp:coordinates = "lon lat" ;
            string antenna_temp:description = "Calibrated scene brightness temperature for each ATMS channel and beam position. This output is the Rayleigh equivalent temperature and not the Planck blackbody equivalent temperature" ;
            antenna_temp:_FillValue = 9.96921e+36f ;
            string antenna_temp:coverage_content_type = "physicalMeasurement" ;
      byte antenna_temp_qc(atrack, xtrack, channel) ;
            antenna_temp_qc:valid_range = 0b, 2b ;

```
          string antenna_temp_qc:long_name = "antenna_temp QC" ;
          string antenna_temp_qc:standard_name = "brightness_temperature status_flag" ;
          string antenna_temp_qc:coordinates = "lon lat" ;
          string antenna_temp_qc:description = "antenna_temp QC flag" ;
          antenna_temp_qc:_FillValue = -1b ;
          string antenna_temp_qc:coverage_content_type = "qualityInformation" ;
          string antenna_temp_qc:flag_meanings = "Best Good Do_Not_Use" ;
          antenna_temp_qc:flag_values = 0b, 1b, 2b ;
     float cold_nedt(channel) ;
          string cold_nedt:units = "Kelvin" ;
          cold_nedt:valid_range = 0.001f, 100.f ;
          string cold_nedt:long_name = "cold NEdT" ;
          string cold_nedt:description = "Noise equivalent delta temperature derived from observations of
cold space" ;
          cold_nedt:_FillValue = 9.96921e+36f ;
          string cold_nedt:coverage_content_type = "qualityInformation" ;
     float warm_nedt(channel) ;
          string warm_nedt:units = "Kelvin" ;
          warm_nedt:valid_range = 0.001f, 100.f ;
          string warm_nedt:long_name = "warm NEdT" ;
          string warm_nedt:description = "Noise equivalent delta temperature derived from observations
of the warm calibration target" ;
          warm_nedt:_FillValue = 9.96921e+36f ;
          string warm_nedt:coverage_content_type = "qualityInformation" ;
     string band_lbl(band) ;
          string band_lbl:long_name = "Band name" ;
          string band_lbl:standard_name = "sensor_band_identifier" ;
          string band_lbl:description = "List of Microwave bands (K, Ka, V, W, G)" ;
          string band_lbl:coverage_content_type = "auxillaryInformation" ;
     ushort channel(channel) ;
          string channel:units = "1" ;
          string channel:long_name = "channel number" ;
          string channel:description = "Number for each channel (1-22)" ;
          channel:_FillValue = 65535US ;
          string channel:coverage_content_type = "auxillaryInformation" ;
     string chan_band(channel) ;
          string chan_band:long_name = "channel band" ;
          string chan_band:description = "Name of band for each channel" ;
          string chan_band:coverage_content_type = "auxillaryInformation" ;
     char antenna(channel) ;
          string antenna:long_name = "antenna name" ;
          string antenna:description = "Name of antenna for each channel" ;
          antenna:_FillValue = "," ;
          string antenna:coverage_content_type = "auxillaryInformation" ;
     float center_freq(channel) ;
          string center_freq:units = "MHz" ;
          string center_freq:long_name = "channel center frequency" ;
          string center_freq:standard_name = "sensor_band_central_radiation_frequency" ;
          string center_freq:description = "Channel center frequency" ;
          center_freq:_FillValue = 9.96921e+36f ;
          string center_freq:coverage_content_type = "auxillaryInformation" ;
     float if_offset_1(channel) ;
          string if_offset_1:units = "MHz" ;
          string if_offset_1:long_name = "first intermediate frequency offset" ;
```

string if_offset_1:description = "Offset of first intermediate frequency stage (zero for no mixing)" ;

        if_offset_1:_FillValue = 9.96921e+36f ;
        string if_offset_1:coverage_content_type = "auxillaryInformation" ;
float if_offset_2(channel) ;
        string if_offset_2:units = "MHz" ;
        string if_offset_2:long_name = "second intermediate frequency offset" ;
        string if_offset_2:description = "Offset of second intermediate frequency stage (zero for no mixing)" ;
        if_offset_2:_FillValue = 9.96921e+36f ;
        string if_offset_2:coverage_content_type = "auxillaryInformation" ;
float bandwidth(channel) ;
        string bandwidth:units = "MHz" ;
        string bandwidth:long_name = "total bandwidth" ;
        string bandwidth:description = "bandwidth of sum of 1, 2, or 4 channels" ;
        bandwidth:_FillValue = 9.96921e+36f ;
        string bandwidth:coverage_content_type = "auxillaryInformation" ;
char polarization(channel) ;
        string polarization:long_name = "Polarization" ;
        string polarization:description = "Nominal polarization: Vertical or Horizontal" ;
        polarization:_FillValue = "," ;
        string polarization:coverage_content_type = "auxillaryInformation" ;
float beam_width(channel) ;
        string beam_width:units = "degree" ;
        string beam_width:long_name = "Beam width" ;
        string beam_width:description = "Nominal beam width" ;
        beam_width:_FillValue = 9.96921e+36f ;
        string beam_width:coverage_content_type = "auxillaryInformation" ;

group: aux {
 variables:
    int geo_qualflag(atrack, xtrack) ;
        string geo_qualflag:long_name = "geolocation quality" ;
        string geo_qualflag:description = "
            Bit 7 - Failed geolocation on Earth topographic surface (surface_loc)
            Bit 6 - Could not set FOV surface elevations and land water fraction (DEM)
            Bit 5 - Failed geolocation on Earth geoid (geoid_loc)
            Bit 4 - Failed to set solar zenith or azimuth angles (solar_ang)
            Bit 3 - Failed to set spacecraft zenith or azimuth angles (spacecraft_ang)
            Bit 2 - Unused (0)
            Bit 1 (LSB) - Failed geolocation of some bands (band_specific)" ;
        geo_qualflag:_FillValue = -2147483647 ;
        string geo_qualflag:coverage_content_type = "qualityInformation" ;
        string geo_qualflag:flag_meanings = "surface_loc DEM geoid_loc solar_ang spacecraft_ang band_specific" ;
        geo_qualflag:flag_values = 64, 32, 16, 8, 4, 1 ;
    int cal_qualflag(atrack, channel) ;
        string cal_qualflag:long_name = "calibration quality flags" ;
        string cal_qualflag:coordinates = "subsat_lon subsat_lat" ;
        string cal_qualflag:description = "(Bit 32 is most significant. It is not used because it can cause confusion when this flag is used as a signed or unsigned integer.)
            Bit 7 : No usable calibration. Scan is not calibrated. (cal_failed)
            Bit 6 : Calibration values used from different scan. (cal_from_diff_scan)
            Bit 5: Insufficient valid shelf temperature values to use in a scan calibration. Fall-back constant shelf temperatures are used. (shelf_temp_bad)

Bit 4: Excess noise (noise)\
it 3: Telemetry out of limits (telem)
Bit 2: Spectral quality is poor (spectral)
Bit 1 (LSB): reserved (0)" ;
cal_qualflag:_FillValue = -2147483647 ;
string cal_qualflag:coverage_content_type = "qualityInformation" ;
string cal_qualflag:flag_meanings = "spectral telem noise shelf_temp_bad cal_from_diff_scan cal_failed" ;
cal_qualflag:flag_values = 2, 4, 8, 16, 32, 64 ;
int cal_space_qualflag(atrack, channel) ;
string cal_space_qualflag:long_name = "space view calibration quality flags" ;
string cal_space_qualflag:coordinates = "subsat_lon subsat_lat" ;
string cal_space_qualflag:description = "(Bit 32 is most significant. It is not used because it can cause confusion when this flag is used as a signed or unsigned integer.)
Bit 14 : Insufficient valid space (cold calibration) observation counts to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (cold_cal_bad)
Bit 13: Insufficient effective space temperature values to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (space_temp_bad)
Bit 12: This scan's space view #1 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv1_bad)
Bit 11: This scan's space view #2 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv2_bad)
Bit 10 : This scan's space view #3 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv3_bad)
Bit 9 : This scan's space view #4 not used because of lunar intrusion or other problem. A scan-specific calibration may still be calculated using space views from neighboring views and scans. (sv4_bad)
Bit 8: Missing moon angle for this scan's space view #1. Lunar intrusion status is unknown. (sv1_moon_unknown)
Bit 7: Missing moon angle for this scan's space view #2. Lunar intrusion status is unknown. (sv2_moon_unknown)
Bit 6: Missing moon angle for this scan's space view #3. Lunar intrusion status is unknown. (sv3_moon_unknown)
Bit 5: Missing moon angle for this scan's space view #4. Lunar intrusion status is unknown. (sv4_moon_unknown)
Bits 1-4: reserved (0)" ;
cal_space_qualflag:_FillValue = -2147483647 ;
string cal_space_qualflag:coverage_content_type = "qualityInformation" ;
string cal_space_qualflag:flag_meanings = "sv4_moon_unknown sv3_moon_unknown sv2_moon_unknown sv1_moon_unknown sv4_bad sv3_bad sv2_bad sv1_bad space_temp_bad cold_cal_bad" ;
cal_space_qualflag:flag_values = 16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 8192 ;
int cal_blackbody_qualflag(atrack, channel) ;
string cal_blackbody_qualflag:long_name = "blackbody calibration quality flags" ;
string cal_blackbody_qualflag:coordinates = "subsat_lon subsat_lat" ;
string cal_blackbody_qualflag:description = "(Bit 32 is most significant. It is not used because it can cause confusion when this flag is used as a signed or unsigned integer.)
Bit 3: Insufficient valid black body (warm calibration) observation counts to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (warm_cal_bad)
Bit 2: Insufficient valid black body temperature readings to produce a scan-specific calibration. Scan may still be calibrated using coefficients from another scan. (bb_temp_bad)
Bit 1 (LSB): This scan's black body view not used. A scan-specific calibration may still be calculated using black body views from neighboring scans. (bb_bad)" ;

```
        cal_blackbody_qualflag:_FillValue = -2147483647 ;
        string cal_blackbody_qualflag:coverage_content_type = "qualityInformation" ;
        string cal_blackbody_qualflag:flag_meanings = "bb_bad bb_temp_bad warm_cal_bad" ;
        cal_blackbody_qualflag:flag_values = 1, 2, 4 ;
float offset(atrack, channel) ;
        string offset:units = "Kelvin" ;
        string offset:long_name = "calibration offset" ;
        string offset:coordinates = "subsat_lon subsat_lat" ;
        string offset:description = "Offset used in calibrating earth scene brightness temps." ;
        offset:_FillValue = 9.96921e+36f ;
        string offset:coverage_content_type = "auxillaryInformation" ;
float gain(atrack, channel) ;
        string gain:units = "Count/Kelvin" ;
        string gain:long_name = "calibration gain" ;
        string gain:coordinates = "subsat_lon subsat_lat" ;
        string gain:description = "Gain factor used in calibrating earth scene brightness temps." ;
        gain:_FillValue = 9.96921e+36f ;
        string gain:coverage_content_type = "auxillaryInformation" ;
float nonlin(atrack, xtrack, channel) ;
        string nonlin:units = "Kelvin" ;
        nonlin:valid_range = 0.f, 400.f ;
        string nonlin:long_name = "nonlinearity correction" ;
        string nonlin:coordinates = "lon lat" ;
        string nonlin:description = "Nonlinearity correction used in calibrating earth scene brightness
temps." ;
        nonlin:_FillValue = 9.96921e+36f ;
        string nonlin:coverage_content_type = "auxillaryInformation" ;
float cold_temp(atrack, channel) ;
        string cold_temp:units = "Kelvin" ;
        string cold_temp:long_name = "cold space temperature" ;
        string cold_temp:coordinates = "subsat_lon subsat_lat" ;
        string cold_temp:description = "Effective temperature of cold calibration view (space) (Tcc)" ;
        cold_temp:_FillValue = 9.96921e+36f ;
        string cold_temp:coverage_content_type = "auxillaryInformation" ;
float warm_temp(atrack, channel) ;
        string warm_temp:units = "Kelvin" ;
        string warm_temp:long_name = "warm calibration temperature" ;
        string warm_temp:coordinates = "subsat_lon subsat_lat" ;
        string warm_temp:description = "Effective temperature of warm calibration view (black body)
(Twc)" ;
        warm_temp:_FillValue = 9.96921e+36f ;
        string warm_temp:coverage_content_type = "auxillaryInformation" ;
 } // group aux
}
```