

NASA SNPP Cross Track Infrared Sounder (CrIS) Level 1B Product Users' Guide

University of Wisconsin-Madison, Space Science and Engineering Center

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2.0 Rev A	2.0.15	21 Jun 2018	First revision of release describing Version 2.0 product. Includes the following changes: <ul style="list-style-type: none"> - Added caveat regarding an ICT radiance model error.
2.0 Rev B	2.0.16	7 Oct 2019	Second revision of release describing Version 2.0 product. Includes the following changes: <ul style="list-style-type: none"> - Describes impact of SNPP mid-wave signal processor failure on Version 2.0 product - Fixed typo in FSR MW dimension size

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1 Introduction

1.1 Overview

This document describes Version 2.0 of the NASA Cross-track Infrared Sounder (CrIS) Level 1B (L1B) data product.

The product consists of calibrated radiance spectra and geolocation information, as well as metadata and various derived parameters related to the observations.

The goal of creating this product is to provide a high-quality, consistently calibrated dataset spanning the Suomi NPP (SNPP) mission, for use in climatology and other applications where long-term stability is a primary consideration.

The Version 2.0 product includes datasets at two different resolutions, which are referred to as Normal Spectral Resolution (NSR) and Full Spectral Resolution (FSR). This was done because the effective spectral resolution of the data sent down from the SNPP satellite was increased several years into the mission, and it was considered useful to produce both a dataset spanning the longest possible duration (NSR) and another at a higher spectral resolution (FSR). The NSR dataset spans seven years to date, and routine generation of both datasets is ongoing at GES DISC.

The file format of the CrIS L1B product is NetCDF4. The Climate and Forecast (CF) and Attribute Convention for Dataset Discovery (ACDD) standards are followed where applicable. The data format and granulation scheme are common with the Advanced Technology Microwave Sounder (ATMS) L1B product, and were developed in collaboration with the ATMS L1B team, located at NASA Jet Propulsion Laboratory (JPL).

On March 26, 2019, a hardware failure occurred in the CrIS mid-wave signal processor on the SNPP satellite. The issue was resolved on June 24, 2019, by switching from the Side 1 electronics to the redundant Side 2 electronics. After the side change, Instrument Line Shape (ILS) parameters were re-tuned and a new L1B software version was released to be used in processing Side 2 data. The primary impact of this event on the L1B product is several months of missing mid-wave data, as well as a short gap in products from all bands immediately after the side change. In addition, there are subtle differences in product characteristics resulting from the different electronics and different parameters used in Side 2 calibration. For more information, refer to Section 3.4.

This product was generated by Versions 2.0.15 (pre-side-change) and 2.0.16 (post-side-change) of the CrIS L1B software, which was developed with funding from NASA at the University of Wisconsin - Madison (UW) Space Science and Engineering Center and the University of Maryland - Baltimore County (UMBC) Atmospheric Spectroscopy Laboratory.

1.2 Data Disclaimer

The Version 2.0 CrIS L1B data product is released to the public as is.

1.3 Obtaining the Product

The CrIS Level 1B product can be downloaded from the Goddard Distributed Active Archive Center (GDAAC).

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

1.4 Contact Information

Inquiries regarding the data product can be directed to sounder.sips@jpl.nasa.gov.

Inquiries regarding the software and underlying algorithms can be directed to cris.l1b.support@ssec.wisc.edu.

1.5 What's New

The differences between the Version 2.0 and the earlier Version 1.0 product are:

- The FSR dataset is provided, in addition to NSR.
- Three top-level Quality Control (QC) variables have been added (`rad_lw_qc`, `rad_mw_qc`, `rad_sw_qc`). These variables are valued 0, 1, or 2 and summarize the quality of the calibrated radiance product for each detector band, with one value per observation.
- The L1b calibration quality flags have been regrouped from a single 64-bit bit-encoded variable to four 32-bit bit-encoded variables. The `cal_qualflag` variable contains quality flag information that is detector band independent. The `cal_lw_qualflag`, `cal_mw_qualflag`, and `cal_sw_qualflag` variables contain quality flag information that is detector band dependent, and each of these three variables has identical bit encoding and information format.
- For {0,1,2} valued Quality Flags the value of 1 now denotes "Good" rather than "Degraded". The logic to set these flags has been changed accordingly.
- The band-guard filter coefficients used within the calibration equation have been optimized.
- The full calibration algorithm is now used to generate the NEDN estimates and imaginary radiances.
- The threshold for the imaginary radiance check is resolution dependent (increases by a factor of $\sqrt{2}$ for MW FSR, and by a factor of 2 for SW FSR).
- Variable `obs_time_tai` has been renamed to `obs_time_tai93`.
- Fixed an issue where the imaginary auxiliary outputs and the NEdN outputs were on a slightly different wavenumber scale than the corresponding calibrated radiances.
- Fixed an issue where NeDN outputs were provided as raw counts instead of radiance units.
- Several new geolocation fields have been added: `local_solar_time`, `sat_sol_zen`, `sat_sol_azi`, `mean_anom_wrt_equat`, `asc_node_tai93`, `asc_node_lon`, `asc_node_local_solar_time`, and `solar_beta_angle`.
- Geolocation now uses a consistent set of field of regard scene mirror angles across all granules instead of relying on values from the engineering packet.
- Improvements to the accuracy of solar-related geolocation variables.
- Fixed the `valid_range` attribute on the `sun_glint_dist` variable, which was erroneously expressed in kilometers instead of meters as documented.

2 Background

2.1 Instrument Description

The Cross-track Infrared Sounder (CrIS) is a Fourier Transform Spectrometer (FTS) onboard the Suomi National Polar-Orbiting Partnership (SNPP) satellite, launched on October 28, 2011 into an orbit with an altitude of 824 km above the Earth surface, an inclination angle of 98.7 deg and a 13:30 local time ascending node [NOAA Technical Report NESDIS 143]. SNPP is the first in a series of next generation U.S. weather satellites of the Joint Polar Satellite System (JPSS).

CrIS is a flat-mirror Michelson interferometer which measures interferograms in three Infrared (IR) bands simultaneously. The CrIS interferometer includes a beamsplitter, a stationary and moving mirror, and a laser sampling system. The scene radiance entering the interferometer is split by the beamsplitter into two beams along two separate paths. One beam travels towards the moving mirror, while the other to a stationary mirror. The two beams are reflected from the corresponding mirrors and recombine before converging on the detector. The optical path difference (OPD) traveled by the two beams is twice the physical path difference between the two mirrors. As the moving mirror sweeps from one side of the zero path difference (ZPD) to the other, a time-varying interference pattern known as the interferogram is recorded. A convolution of the interferogram with a Finite Impulse Response (FIR) numerical filter is applied in real-time on the spacecraft to reduce the internal data rate to meet telemetry requirements. This results in a complex-valued interferogram of a fixed number of sample points which is included in the downlinked data packets.

During a single scene scan mirror dwell period, one interferogram is recorded for each of 27 detectors simultaneously (3 focal planes (LW, MW, SW) each containing 9 bore-sighted detectors in a 3x3 pattern). The CrIS uses a 45 deg scene scan mirror to provide sequential views of an internal blackbody (ICT), a deep space view (DS), and 30 Earth views in the cross-track in a repeating pattern as the spacecraft moves along-track. The interferograms associated with the ICT and DS views and a measurement of ICT temperature are used in the ground processing software to calibrate the Earth views to produce radiance spectra. Prior to calibration, a correction is applied to account for measured signal nonlinearity of selected detectors. Corrections are also applied in the ground processing software to remove FTS self-apodization effects and to resample the spectra to a predefined user spectral grid.

2.2 Resolution of SNPP Instrument Data

For the first part of the SNPP mission, the effective spectral resolution of CrIS data received from the satellite was lower in the short-wave and mid-wave infrared bands than in the long-wave infrared band. Level 0 data received during this initial period is referred to as Normal Spectral Resolution (NSR).

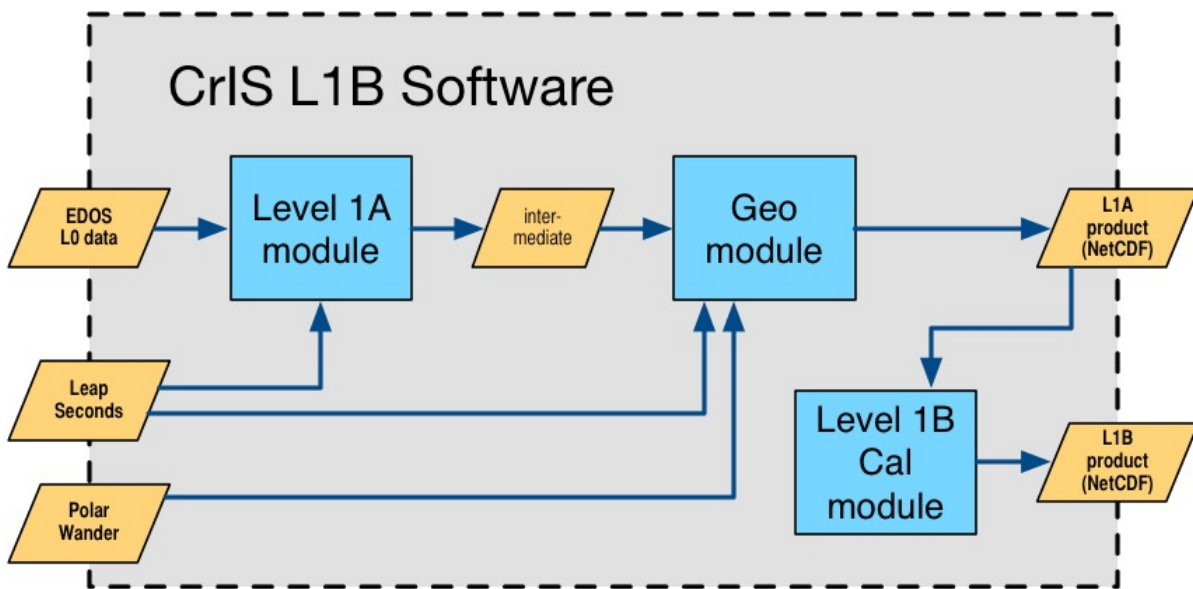
On December 4, 2014, the resolution of the short-wave and mid-wave data transmitted from the satellite was increased to match the long-wave resolution. Level 0 data received from this time through November 2, 2015 is referred to as Full Spectral Resolution (FSR). After the transition to FSR, the effective spectral resolution of short-wave data received on the ground was quadrupled, and the effective spectral resolution of mid-wave data was doubled, with the Level 0 data volume increasing accordingly.

On November 2, 2015, the satellite began transmitting long-wave and short-wave interferograms with extra points on the ends. Level 0 data received from this time onward is referred to as Extended Spectral Resolution (XSR). These points had previously been discarded, but were added to the data stream because it was determined that they could be used to improve the quality of the calibration.

2.3 Algorithm Background

The CrIS L1B software consists of three main processing modules: Level 1A (L1A), Geolocation and L1B Calibration. The controlling “glue” logic is written in Bash and Python.

Figure 2.3- 1 CrIS L1B software modules and data flow



The L1A and Geolocation modules were developed as mostly new code, written in Python. The L1B Calibration module is written in Matlab and is based on the CrIS Calibration Algorithm and Sensor Testbed (CCAST) software developed at the UW and UMBC. The CCAST software was modified for this project to be compatible with the new L1A and Geo products. Additionally, modifications to the calibration algorithm and quality flag indicators have been incorporated.

For information on the theoretical basis of the CrIS L1B Version 2.0 software, refer to the “NASA SNPP Cross Track Infrared Sounder (CrIS) Level 1B Delta Algorithm Theoretical Basis Document (ATBD), Version 2.0”. That document describes algorithm differences relative to the JPSS SDR ATBD document.

2.4 Product Generation

Software integration was done by the SNPP Sounder Science Investigator-led Processing System (SIPS), located at JPL and Goddard Earth Sciences Data Information Services Center

(GES DISC). The product was generated from EOS Data and Operations System (EDOS) Level 0 data at GES DISC.

3 CrIS L1B Product

3.1 3.1 Granulation

The data is partitioned into 6-minute granules, with one granule per file and 240 granules per day. Granules are aligned to Coordinated Universal Time (UTC) such that the nominal start time of the first granule of the day is 00:00Z, and the nominal start time of the last granule is 23:54Z.

Each granule is composed of 45 complete 8-second scans. A complete scan is included in a granule if its start time is between the nominal granule start and end times. Note that because granules are UTC-aligned and contain only complete scans, the actual data start time may be up to eight seconds after the nominal granule start time. This actual-versus-nominal time delta is generally stable, but changes after each UTC leap second adjustment.

The CrIS and ATMS products use the same granulation scheme, so that CrIS and ATMS granules can be easily matched via the filenames or file metadata. However, note that the temporal and spatial alignment of the data will not be perfect due to differences in the CrIS and ATMS scan start times and footprints.

It is notable that the granulation occurs during L1A processing and uses direct telemetry times. In the case of CrIS, earth scene, deep space, and internal calibration target observation times are corrected backward from telemetry times to reflect the center of the interferometer scan. This correction is done using a delta value provided by the instrument in the 4-minute engineering telemetry. As a result, the first earth scene observation time can and does sometimes land slightly (milliseconds) before the nominal start of a 6-minute UTC-aligned CrIS L1A or L1B granule. This situation occurs after the 20161231T235960 leap second adjustment and prior to the following (future) leap second adjustment.

3.2 Product Files

L1A and L1B products are written to separate files, with the same granulation.

The L1A product consists of raw telemetry values that have been decoded and unscaled, as well as bit-trimmed interferograms, geolocation data, quality flags and other metadata. The L1A product **is not** described in this document.

The L1B product consists of calibrated radiance spectra and the associated NEdN, auxiliary data including imaginary spectra, geolocation data (identical to L1A), quality flags and other metadata. The L1B product **is** described in this document.

3.3 NSR vs FSR Product Datasets

As described in Section 2.2, the resolution of CrIS data as received from the satellite was increased several years into the SNPP mission. For the Version 2.0 product, it was decided to produce L1B datasets at two different resolutions, to meet the goals of providing a spectrally consistent product with the longest possible duration and also with the highest possible spectral resolution. These L1B datasets are referred to as NSR and FSR.

The NSR dataset has a lower resolution in the short-wave and mid-wave spectra compared to the long-wave, consistent with the Version 1.0 product. The start date is April 19, 2012, which was determined to be the earliest date in the SNPP mission where the data received from the satellite was of sufficient quality to produce a consistent product. Input Level 0 short-wave and mid-wave interferograms from the FSR part of the mission are truncated to NSR prior to calibration, to maintain consistent spectral characteristics for the entire mission.

The FSR dataset has the same spectral resolution in all three bands, and has a later start date of November 2, 2015. This is the date when extra points were added to the data stream, allowing a better calibration. The FSR dataset is new in Version 2.0.

Table 3.3- 1 Comparison of NSR and FSR L1B datasets

	NSR L1B dataset	FSR L1B dataset
Start date	April 19, 2012 (granule 001)	November 2, 2015 (granule 162)
Long-wave resolution (cm ⁻¹)	0.625	0.625
Mid-wave resolution (cm ⁻¹)	1.25	0.625
Short-wave resolution (cm ⁻¹)	2.5	0.625

The NSR and FSR datasets are distributed as separate files. The resolution of a file can be determined by the `product_name_type_id` field in the filename, as well as the corresponding file attribute, as described in Section 4.4 File Naming.

3.4 Impact of SNPP CrIS Mid-wave Signal Processor Failure

On March 26, 2019, a hardware failure occurred in the CrIS mid-wave signal processor on the SNPP satellite. The issue was resolved on June 24, 2019, by switching from the Side 1 electronics to the redundant Side 2 electronics.

After the side change, calibration parameters were tuned and a new L1B software version was released to process the Side 2 data. Consequently, two different software versions are used to produce the v2.0 L1B product: v2.0.15 software for Side 1 data and v2.0.16 software for Side 2 data. In addition, a different product version number has been assigned before and after the side change, as indicated in product file names and the relevant file attributes.

The impacts of the signal processor failure on the SNPP L1B product are:

- Quality issues in mid-wave beginning on about March 24, 2019, followed by several months of missing mid-wave data between March 26, 2019 (granule 180) and June 25, 2019 (granule 214). These issues are indicated in quality flags in the L1B product.
- Missing long-wave and short-wave data for several hours on March 27, 2019, due to an attempt to resolve the issue by restarting the instrument.

- The functioning SNPP long-wave and short-wave band calibrated radiances may exhibit small differences compared to the earlier product after restart on Side 1 on March 27, 2019 and until the Side 2 switch. This is because the missing mid-wave band was required for centering the zero path difference (ZPD) of the CrIS sensor,
- Missing long-wave and short-wave data between June 24, 2019 (granule 159) and June 25, 2019 (granule 214), immediately after the side change and before the instrument stabilized.
- Small differences in the product before and after the side change due to an adjustment of the ILS parameters to account for a change in the focal plane positions for each of the SNPP long-wave, mid-wave and short-wave detector arrays. No other parameters were changed.

4 File Format and Conventions

The CrIS L1B file format is similar to the ATMS L1B file format, sharing common naming conventions, file and variable attributes, and overall file organization. Both CrIS and ATMS L1B products are written and distributed as NetCDF4 files.

4.1 NetCDF4

The product files can be read and queried using the NetCDF4 library and tools maintained by Unidata (<http://www.unidata.ucar.edu/software/netcdf/>). Support for reading NetCDF is offered in many programming languages, including Python, Matlab, IDL, C/C++ and Fortran.

NetCDF4 files are legal HDF5 files with additional bookkeeping information managed by the NetCDF4 library. It is therefore possible to inspect and read data from the NetCDF4 files by using the HDF5 utilities and libraries maintained by the HDF Group (https://www.hdfgroup.org/products/hdf5_tools/index.html) or by using the HDF5 interface in your favorite programming language. However, the two libraries should not be considered fully interchangeable.

Example code showing how to read the files is shown in “Appendix A”.

Matlab users should note that the Matlab NetCDF4 interface is currently (as of version R2017a) not able to read variables that are arrays of strings, and will throw an exception if that is attempted. The workaround is to use the HDF5 interface to read those variables. See “Appendix A” for an example.

4.2 Metadata Conventions

Where possible, the attributes and file structure conform to the Climate and Forecasting (CF) Conventions, Version 1.6, as well as the Attribute Conventions for Data Discovery (ACDD), Version 1.3. These conventions are intended to allow CF-aware software to understand the data, and to improve usability of data by standardizing the representation.

For more information on CF, refer to:

<http://cfconventions.org/>

For more information on ACDD, refer to:

http://wiki.esipfed.org/index.php?title=Category:Attribute_Conventions_Dataset_Discovery

4.3 Missing Data

Missing data is represented by a fill value, as recommended by the CF convention. For each product variable the fill value is indicated by the attribute “_FillValue”. Every data point should be checked for fill before it is used.

4.4 File Naming

File names are composed of multiple fields, separated by the "." character:

```
<product_name_project>.<product_name_platform>.<product_name_instr>.<gran_id>.<product_name_duration>.<granule_number>.<product_name_type_id>.<product_name_variant>.<product_name_version>.<product_name_producer>.<product_name_timestamp>.<product_name_extension>
```

The fields are described in the table below. For each field in the filename there is a corresponding attribute in the global metadata in the file, as shown in the table.

Table 4.4- 1 CrIS L1B Filename Fields

Filename field / attribute name in file	Format	Value(s) in V2 product	Description
product_name_project	nnnn	SNDR	Sounder SIPS ID
product_name_platform	pppp	SNPP	Satellite platform
product_name_instr	iiii	CRIS	Instrument ID
gran_id	yyyymmddThhmm		Unique ID identifying granule (nominal granule start time)
product_name_duration	m##	m06	6 minute product granularity
granule_number	g###	g001 – g240	Granule number
product_name_type_id	(freeform text)	L1B or L1B_NSR	Product type, where L1B indicates FSR, L1B_NSR indicates NSR
product_name_variant	(freeform text)	std	Used to identify special runs. The default is: std = standard.
product_name_version	v02_##		Product version, e.g. "v02_05"
product_name_producer	p	G	Production location: Goddard Space Flight Center
product_name_timestamp	yymmddhhmmss		Time file was produced
product_name_extension	nc	nc	NetCDF file extension

Example filename:

```
SNDR.SNPP.CRIS.20160101T0012.m06.g003.L1B.std.v02_05.G.180315115022.nc
```


4.5 Time Representation

Times in the CrIS 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 that is received from the satellite, observation times are represented as UTC.

Timestamps in CrIS 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:

```
2016-01-25T13:00Z
20160125T1300
```

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 CrIS 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.

5 Data Contents

CrIS L1B data is stored in NetCDF4 format data files and requires a recent version of the Unidata NetCDF library to access content. NetCDF4 is effectively a specialization of the HDF5 format, unlike NetCDF3 and prior versions. Some users may prefer to use HDF5 libraries to access the files; doing so is subject to a number of caveats outside the scope of this document.

The NetCDF4 data model allows for variables, groups (similar to directories in a file system), dimensions and attributes.

Most of the variables in the CrIS L1B files are at the root level. However, auxiliary variables, which are mainly useful for diagnostic and validation purposes, are contained in a group called "aux".

Each variable has attributes recommended by the Unidata Climate and Forecasting (CF) convention, sufficient to describe the meaning of the variable and interpret its value. Each file has a set of standard-conforming global attributes that describe the granule, including geographic information, quality flag summary statistics, and data provenance.

This section describes the variables, dimensions and attributes in the CrIS L1B files. For a complete list in Common Data form Language (CDL) format, refer to "Appendix B".

5.1 Dimensions

The key dimensions are:

Common:

```
atrack = 45; // along-track spatial dimension
xtrack = 30; // cross-track spatial dimension
fov = 9; // field-of-view dimension
```

NSR dataset only:

```
wnum_lw = 717; // long-wave IR wavenumber dimension
wnum_mw = 437; // mid-wave IR wavenumber dimension
wnum_sw = 163; // short-wave IR wavenumber dimension
```

FSR dataset only:

```
wnum_lw = 717; // long-wave IR wavenumber dimension
wnum_mw = 869; // mid-wave IR wavenumber dimension
wnum_sw = 637; // short-wave IR wavenumber dimension
```

5.2 Global Attributes

There are many global (i.e. file-level) attributes that provide information about the granule, including geographic information, data provenance, and the range of observation times. Many of these attributes are recommended by the CF and ACDD standards, and some are provided for consistency with legacy products. Due to the goal of complying with multiple standards,

the attributes do not follow a single naming convention, and some attributes may contain duplicate information.

Some global attributes are static, i.e. unvarying across files, some are set by the operator (typically the NASA GES DISC) via configuration files, and some are set dynamically at runtime by the L1B software based on the data being processed.

The table below describes the dynamic global attributes. For a full list of global attributes, refer to "Appendix B: CDL Files".

Table 5.2- 1 CrIS L1B Dynamic Global Attributes

Attribute Name	Type	Description	Heritage
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.	ECS. AIRS called it AutomaticQAFlag in HDF attributes but AutomaticQualityFlag in metadata.
comment	string	Miscellaneous information about the data or methods used to produce it. Can be empty.	CF, ACDD Recommended
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.	ACDD Recommended, ECS/AIRS ProductionDateTime
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.	AIRS DayNightFlag
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	ACDD Recommended

		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_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.	ACDD Recommended
geospatial_lat_mid	float	Granule center latitude	AIRS LatgranuleCen
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.	ACDD Recommended
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, 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).	ACDD Recommended
geospatial_lon_mid	float	Granule center longitude	AIRS LonggranuleCen
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.	ACDD Recommended
gran_id	string	Unique granule identifier yyyymmddThhmm of granule start	
granule_number	ushort	granule number of day (1-240)	AIRS
history	string	Provides an audit trail for modifications to the original data.	CF, ACDD Recommended
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.	ISO Source Creation Date
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.	ECS InputPointer; ISO Source Citation
input_file_types	string	Semicolon-separated list of tags giving the role of each input file in	ISO Source Description

		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.	SMAP uses this attribute name but only asc/desc because files are half orbits. The values used here are similar to AIRS node_type.
processing_level	string	A textual description of the processing (or quality control) level of the data. "Dummy" when file contains no data.	ACDD Recommended
product_name	string	Canonical fully qualified product name (official file name)	ECS LocalGranuleID
product_name_granule_number	string	zero-padded string for granule number of day (g001-g240)	AIRS
product_name_timestamp	string	Processing timestamp as it appears in product_name (yymmddhhmmss)	
production_host	string	Identifying information about the host computer for this run. (Output of linux "uname -a" command.)	
qa_no_data	string	A simple indicator of whether this is an "empty" granule with no data from the instrument. "TRUE" or "FALSE".	
qa_pct_data_geo	float	Percentage of expected Earth observations that are successfully geolocated.	Maps to (part of) ISO 19115 CompletenessComission
qa_pct_data_missing	float	Percentage of expected observations that are missing.	ECS, maps to (part of) ISO 19115 CompletenessComission
qa_pct_data_sci_mode	float	Percentage of expected Earth observations that were taken while the instrument was in science mode and are successfully geolocated.	Maps to (part of) ISO 19115 CompletenessComission
time_coverage_duration	string	Describes the duration of the data set.	ACDD Recommended
time_coverage_end	string	Nominal end time. Describes the time of the last data point in the data set.	ACDD Recommended
time_coverage_mid	string	Describes the midpoint between the nominal start and end times.	Sounder SIPS extension by analogy with ACDD time_coverage_start and time_coverage_end
time_coverage_start	string	Nominal start time. Describes the time of the first data point in the data set.	ACDD Recommended
time_of_first_valid_obs	string	Describes the time of the first valid data point in the data set.	
time_of_last_valid_obs	string	Describes the time of the last valid data point in the data set.	

5.3 Variable Attributes

Variables in the NetCDF files may have the attributes shown in the table below. For a more detailed description of the standard-conforming attributes, refer to the relevant standard as noted.

Table 5.3- 1 CrIS L1B Variable Attributes

Attribute	Type	Relevant Standard(s)	Description
units	string	CF, udunits	Units, for variables that represent physical quantities
_FillValue	(same as variable)	CF, NetCDF	A single sentinel value indicating the data point contains fill instead of valid data
standard_name	string	CF	Standard name from the CF standard name table, if one exists for the quantity being represented
long_name	string	CF	A longer name describing the quantity being represented, suitable for a plot title
valid_range	(same as variable)	CF	A pair of values indicating the minimum and maximum values to be considered valid
coordinates	string	CF	A space-separated list of the names of other variables that are coordinates for this variable
description	string		A longer description of the quantity being represented
coverage_content_type	string	ACDD, ISO 19115-1	Indicates the source of the data
ancillary_variables	string	CF	A space-separated list of the names of other variables that contain information about this variable
bounds	string	CF	Defines the extent, for cell variables
cell_methods	string	CF	Describes statistical methods used to derive data, for cell variables
flag_values	(same as variable)	CF	A comma-separated list of flag values, for variables that represent flags
flag_meanings	string	CF	A space separated list of the meanings of each flag value, for variables that represent flags
flag_masks	(same as variable)	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"

5.4 Variables

Variables in the NetCDF product files can be grouped in the following categories: science data, auxiliary, geolocation and quality information. These sets of variables are described in the following sections.

5.5 Science Variables

The science variables in the product files include radiance spectra, NEdN, and other information to be used in interpreting the spectra. These variables are located in the file at the root level.

Quality information should be checked before using the data in science variables (see “Section 5.8 Quality Information”).

The radiance spectra include two guard channels on the ends of each spectral band, such that Hamming apodization may be applied to the spectra while retaining the full band-width of the NOAA SDR product.

Observation times are provided for each spectrum in both International Atomic Time (TAI) and human-readable Coordinated Universal Time (UTC) format.

The UTC observation time variable “obs_time_utc” is an 8-tuple of 16-bit unsigned integers: year (4-digit), month (1-12), day (1-31), hour (0-23), minute (0-59), second (0-60), millisecond (0-999), microsecond (0-999). For most users this will be the preferred time representation.

Refer to Section 4.5 for more information on time representation.

Table 5.5- 1 CrIS L1B Science Variables

Variable Name	Type	Dims	Units	Description
! Radiance spectra				
rad_lw	float32	atrack, xtrack, fov, wnum_lw	mW/(m ² sr cm ⁻¹)	Long-wave real spectral radiance
rad_mw	float32	atrack, xtrack, fov, wnum_mw	mW/(m ² sr cm ⁻¹)	Mid-wave real spectral radiance
rad_sw	float32	atrack, xtrack, fov, wnum_sw	mW/(m ² sr cm ⁻¹)	Short-wave real spectral radiance
! NEdN				
nedn_lw	float32	fov, wnum_lw	mW/(m ² sr cm ⁻¹)	Long-wave noise equivalent differential radiance
nedn_mw	float32	fov, wnum_mw	mW/(m ² sr cm ⁻¹)	Mid-wave noise equivalent differential radiance
nedn_sw	float32	fov, wnum_sw	mW/(m ² sr cm ⁻¹)	Short-wave noise equivalent differential radiance
! Auxiliary coordinate variables plus others giving info on the dimensions				
scan_sweep_dir	ubyte	xtrack	1	Sweep direction of FOVs within a scan: 0 = forward, 1 = reverse
for_num	ubyte	xtrack	1	Field of regard number: 1 to 30
fov_num	ubyte	fov	1	Field of view number: 1 to 9
! CrIS channel characterization				
wnum_lw	float64	wnum_lw	cm ⁻¹	Long-wave wavenumber
wnum_mw	float64	wnum_mw	cm ⁻¹	Mid-wave wavenumber
wnum_sw	float64	wnum_sw	cm ⁻¹	Short-wave wavenumber
! Times and associated metadata				
obs_time_tai93	double	atrack, xtrack	seconds since 1993-01-01 00:00	Earth view observation midtime for each fov

obs_time_utc	uint16	atrack, xtrack, utc_tuple	1	UTC earth view observation time as an array of integers: year, month, day, hour, minute, second, millisecond, microsecond
utc_tuple_lbl	string	utc_tuple		Names of the elements of UTC when it is expressed as an array of integers: year, month, day, hour, minute, second, millisecond, microsecond
! Instrument state				
instrument_state	ubyte	atrack, xtrack, fov	1	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 or spacecraft maneuver); 2/'Erroneous' - Data is not usable (ex: checksum error); 3/'Missing' - No data was received.

5.6 Auxiliary Variables

Auxiliary variables, including imaginary spectra and various calibration parameters, are located in the group called “aux”. For more information on auxiliary variables, refer to “Appendix B: CDL File”.

5.7 Geolocation Variables

Geolocation variables 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. Geolocation variables are located in the file at the root level.

Quality information should be checked before using data in geolocation variables (see “5.8 Quality Information”).

Observation locations are calculated by finding the intersection of the sensor’s line-of-sight both with a model of the earth’s geoid (approximating sea level at all earth locations) and also with a digital elevation model of the earth’s terrain. The resulting earth locations are reported separately as lat_geoid/lon_geoid for the former case and as simply lat/lon for the latter. All other geolocation variables based on earth location are derived from the terrain-corrected (lat/lon) values.

Table 5.7- 1 CrIS L1B Geolocation Variables

Variable Name	Type	Dims	Units	Description
! Basic geolocation				
lat	float	atrack, xtrack, fov	degrees_north	terrain-corrected latitude of fov center
lon	float	atrack, xtrack, fov	degrees_east	terrain-corrected longitude of fov center
lat_bnds	float	atrack, xtrack, fov, fov_poly	degrees_north	latitudes of points forming a polygon around the perimeter of the fov
lon_bnds	float	atrack, xtrack, fov, fov_poly	degrees_east	longitudes of points forming a polygon around the perimeter of the fov
land_frac	float	atrack, xtrack, fov	1	land fraction over the fov

surf_alt	float	atrack, xtrack, fov	m	mean surface altitude wrt earth model over the fov
surf_alt_sdev	float	atrack, xtrack, fov	m	standard deviation of surface altitude within the fov
lat_geoid	float	atrack, xtrack, fov	degrees_north	latitude of FOV center on the geoid (without terrain correction)
lon_geoid	float	atrack, xtrack, fov	degrees_east	longitude of FOV center on the geoid (without terrain correction)
! Solar geometry				
sun_glint_lat	float	atrack	degrees_north	sun glint spot latitude at scan_mid_time
sun_glint_lon	float	atrack	degrees_east	sun glint spot longitude at scan_mid_time
sol_zen	float	atrack, xtrack, fov	degree	solar zenith angle at the center of the fov
sol_azi	float	atrack, xtrack,fov	degree	solar azimuth angle at the center of the fov
sun_glint_dist	float	atrack, xtrack,fov	m	distance of sun glint spot to the center of the fov
local_solar_time	float	atrack, xtrack,fov	hours	local apparent solar time in hours from midnight
sat_sol_zen	float	atrack	degree	solar zenith angle at the satellite
sat_sol_azi	float	atrack	degree	solar azimuth angle at the satellite (clockwise from North)
solar_beta_angle	float		degree	Beta angle for the spacecraft orbit, determining the percentage of the orbit that the spacecraft is in direct sunlight
! FOV / satellite geometry				
view_ang	float	atrack, xtrack, fov	degree	off nadir pointing angle
sat_zen	float	atrack, xtrack, fov	degree	satellite zenith angle at the center of the fov
sat_azi	float	atrack, xtrack, fov	degree	satellite azimuth angle at the center of the fov
sat_range	float	atrack, xtrack, fov	m	line of sight distance between satellite and fov center
! Spacecraft geolocation and associated metadata				
asc_flag	ubyte	atrack	1	ascending orbit flag: 1 if ascending, 0 descending
subsat_lat	float	atrack	degrees_north	sub-satellite latitude at scan_mid_time
subsat_lon	float	atrack	degrees_east	sub-satellite longitude at scan_mid_time
scan_mid_time	double	atrack	seconds since 1993-01-01 00:00	TAI93 at middle of earth scene scans
sat_alt	float	atrack	m	satellite altitude wrt earth model at scan_mid_time
sat_pos	float	atrack, spatial	m	satellite ECR position at scan_mid_time
sat_vel	float	atrack, spatial	m s-1	satellite ECR velocity at scan_mid_time
sat_att	float	atrack, attitude	degree	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.
asc_node_lon	float		degrees_east	Longitude of the last ascending node of spacecraft orbit before time_coverage_end
asc_node_tai93	double		seconds since 1993-01-01 00:00	TAI93 time of the last ascending node of spacecraft orbit before time_coverage_end
asc_node_local_solar_time	float		hours	local apparent solar time at the last ascending node before time_coverage_end in hours from midnight
mean_anom_wrt_equat	float	atrack	degree	spacecraft mean anomaly measured with respect to the ascending node
attitude_lbl	string	attitude		List of rotational directions (roll, pitch, yaw)
spatial_lbl	string	spatial		List of spatial directions (X, Y, Z)

5.8 Quality Information

L1B files contain quality control (QC) variables that describe the overall quality of the calibrated radiances. In addition, the L1A and L1B files contain bit-level quality flag (QF) variables that describe in greater detail any issues that affect the calibrated radiances and geolocation. Users should check quality information before using spectra or geolocation data in analysis or processing.

A more complete description of quality information, including the meaning and derivation of bit-fields, is provided in the document “Cross-track Infrared Sounder (CrIS) Level 1B Quality Flags Description Document, Version 2.0”.

5.8.1 Quality Control

For the v2.0 release, three top-level Quality Control (QC) variables have been added (rad_lw_qc, rad_mw_qc, rad_sw_qc). These variables are valued 0, 1, or 2 and summarize the quality of the calibrated radiance product for each detector band, with one value per observation. A value of 0 indicates no quality issues detected; a value of 1 indicates minor quality issues detected, and while the product may be slightly degraded it is likely of acceptable quality for most end-users; and a value of 2 indicates that the product is invalid, do not use.

Table 5.8.1- 1 Quality Control Variables

Variable name	Type	Dims	Description
rad_lw_qc	byte	atrack, xtrack, fov	Top level L1b quality indicator for LW band, describing the variable rad_lw.
rad_mw_qc	byte	atrack, xtrack, fov	Top level L1b quality indicator for MW band, describing the variable rad_mw.
rad_sw_qc	byte	atrack, xtrack, fov	Top level L1b quality indicator for SW band, describing the variable rad_sw.

5.8.2 Quality Flags

QF variables are bit-fields, composed of flags which can be one or more bits in length. For each QF variable, an overall integer value of 0 (all bits set to 0) indicates good quality. A non-zero value indicates that a problem with inputs or processing was encountered, and that as a result the associated observation failed one or more quality tests. Users can access the individual flags for information on the specific issues that were encountered.

For the v2.0 release, the L1b calibration quality flags have been regrouped from a single 64-bit bit-encoded variable to four 32-bit bit-encoded variables. The `cal_qualflag` variable contains quality flag information that is detector band independent. The `cal_lw_qualflag`, `cal_mw_qualflag`, and `cal_sw_qualflag` variables contain quality flag information that is detector band dependent, and each of these three variables has identical bit encoding and information format for the LW, MW, and SW bands, respectively. No new quality flags have been added for v2.0, but the QF logic has been adjusted where necessary for the change in the definition of a QF value of 1 to 'good' from 'degraded' for {0,1,2} valued QFs.

Note that the meanings of these flags are fully described by the attributes "flag_values", "flag_meanings" and "flag_masks", as recommended by the CF standard. It is recommended that any software that is developed to decode individual flags should use these attributes directly to interpret the meaning of the values, instead of relying on the information in this document. For information on how to apply these attributes, refer to the CF standard.

The array dimensions of the QF variables correspond to the dimensions of the main product variables (radiances, latitudes and longitudes), so that there is a QF element describing each observation.

The primary quality test for each spectrum applies an envelope to the imaginary residual at certain wavenumber regions, and sets the flag to non-zero (bad) if the threshold is exceeded.

If additional quality tests are added in a future product version, we plan to maintain the position and meanings of the currently defined flags to avoid negatively affecting software that was developed using the current product.

Table 5.8.2- 1 CrIS L1B Quality Flag Variables

Variable Name	Type	Dims	Description
<code>/aux/geo_qualflag</code>	int32	atrack, xtrack, fov	Indicates geolocation quality for each observation
<code>cal_lw_qualflag</code>	int32	atrack, xtrack, fov	Indicates L1B quality details for each LW band observation
<code>cal_mw_qualflag</code>	int32	atrack, xtrack, fov	Indicates L1B quality details for each MW band observation
<code>cal_sw_qualflag</code>	int32	atrack, xtrack, fov	Indicates L1B quality details for each SW band observation
<code>cal_qualflag</code>	int32	atrack, xtrack, fov	Indicates L1B non-band specific quality details for each observation

5.9 Granule and Observation IDs

Included in the product are IDs that allow a granule or observation to be uniquely identified. Users are encouraged to refer to these IDs to unambiguously identify datasets within a product, for example when plotting data or publishing results.

Granule ID: Each granule has a unique ID that is stored in a global attribute called “gran_id”, which also appears in the filename. This attribute is a string representation of the nominal start time of the granule. The format of the string is “yyyymmddThhmm”.

For example:

20160125T1300

Observation ID: Each field of regard (FOR), defined as a set of 9 simultaneously observed fields of view, has a globally unique ID stored in the variable “obs_id”. The observation ID is created from the granule ID, with information appended to identify the FOR observation within the granule.

The dimensions of this variable (atrack=45, xtrack=30) correspond to the first two dimensions of the science data variables, such as radiances. An observation ID can be associated with data by applying the same indices into these common dimensions.

The format of the observation ID string is “yyyymmddThhmm.aaExx”, where “aa” is the 2-digit along-track index (01-45), and “xx” is the 2-digit cross-track index (01-30). The “E” indicates that it is an earth view.

For example:

20160125T1300.01E18

FOV Observation ID: At the finest level of granularity, each field of view (FOV) within a FOR observation has a globally unique ID that is stored in a variable called “fov_obs_id”. The FOV observation ID is created from the observation ID, with extra information appended to identify the FOV within the FOR observation.

The dimensions of this variable (atrack=45, xtrack=30, fov=9) correspond to the first three dimensions of the science data variables, such as radiances. A FOV observation ID can be associated with data by applying the same indices into these common dimensions.

The format of the FOV observation ID string is “yyyymmddThhmm.aaExx.f” where “f” is the 1-digit FOV number (1-9).

For example

20160125T1300.01E18.6

Table 5.9- 1 Observation ID Variables

Variable Name	Type	Dims	Units	Description
obs_id	string	atrack, xtrack		Unique earth view observation identifier: yyyymmddThhmm.aaExx. Includes gran_id plus 2-digit along-track index (01-45) and 2-digit cross-track index (01-30).
fov_obs_id	string	atrack, xtrack, fov		Unique earth view observation identifier for FOV: yyyymmddThhmm.aaExx.f. Includes obs_id plus 1-digit FOV number (1-9).

6 Caveats and Known Issues

This section describes known issues affecting the CrIS L1B Version 2.0 product.

1. Due to leap second correction delays known to have occurred in the SNPP CrIS instrument system, products may not be produced surrounding leap second transitions. Full resolution of this issue may not be available until JPSS-1 CrIS or later.
2. In some instances, a fill value may be inadvertently represented by a NaN in the v2.0 product rather than the CF compliant fill value. It is recommended that end users consider both the CF compliant fill value and a NaN value as 'fill-values' in the v2.0 L1b product.
3. Further refinement of the lunar intrusion check algorithm is still desirable. The current algorithm is based on the IDPS method but has been modified to account for the issues identified in that method, and incorporates tighter thresholds in v2.0 than used in the IDPS software.
4. The criteria for setting the summary flags in the band-specific QF variables and the corresponding QC values to "good" will be reviewed for a future release. Currently an observation can be marked "good" even if geolocation failed, but this is not expected to happen frequently.
5. A false positive for Imaginary Radiance Anomaly may be indicated for extremely hot scenes, resulting in non-zero values in band-specific quality flag and quality control variables. Threshold values and algorithm optimization will be reviewed prior to the v3.0 release.
6. Spectral Calibration Quality currently is set to 1 (Good) in the band-specific QF variables for the case in which the ISA Degraded flag is clear, but the Neon Cal Quality Flag is set. It is expected that there are very few instances for which this combination occurs, but this logical test will be reviewed prior to the v3.0 release.
7. Under certain rare circumstances, the AutomaticQualityFlag attribute may be erroneously set to a degraded value (e.g. set to "Suspect" instead of "Passed", or set to "Failed" instead of "Suspect").
8. For some granules, the qa_pct_data_missing attribute may be higher than it should be, due to spectra with a QC value that is > 0 ("good" or "do_not_use") being erroneously counted as missing.
9. The type of the variables rad_lw_qc, rad_mw_qc and rad_sw_qc may be changed from byte to ubyte in a future release.
10. An interpolation error of the engineering packet ICT emissivity to the FSR wavenumber scale results in a very small error in the calibrated radiance. Expressed in brightness temperature at scene temperature, this error is expected to be less than 0.01K for the LW and SW bands and less than 0.05K for the MW for most scenes. This issue will be resolved in the v3.0 release.

7 References

1. NASA SNPP Cross Track Infrared Sounder (CrIS) Level 1B Delta Algorithm Theoretical Basis Document (ATBD), Version 2.0
2. Cross-track Infrared Sounder (CrIS) Level 1B Quality Flags Description Document, Version 2.0
3. Joint Polar Satellite System (JPSS) Cross Track Infrared Sounder (CrIS) Sensor Data Records (SDR) Algorithm Theoretical Basis Document (ATBD), Rev C, Code 474, 474-00032
4. 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
5. NetCDF Climate and Forecast (CF) Metadata Conventions, Version 1.6, December 2011 (<http://cfconventions.org/cf-conventions/v1.6.0/cf-conventions.pdf>)

Appendix A: Example Data Ingest Code

1. Python code snippet, showing how to read the variable “rad_lw” from a file and grab a single spectrum. *rad_mw* and *rad_sw* variables are accessed similarly and have corresponding *wnum_{l,m,s}*w wavenumber vectors.

```
import netCDF4 as nc4
ncf = nc4.Dataset(filename, 'r')
rad_lw = ncf.variables['rad_lw']
atrack, xtrack, fov = 0, 0, 0
spectrum = rad_lw[atrack, xtrack, fov, :]
wnum_lw = ncf.variables['wnum_lw']
wavenumbers = wnum_lw[:]
```

2. Matlab code snippet, showing a simple function to read the root-level variables from a file. Note that this function reads the file as an HDF5 file for certain variable types not supported by the MATLAB NetCDF API.

```
function s = read_netcdf_lls(fn);
% A generic reader for netcdf files. Only reads first-level
groups
% Top Level
ni = ncinfo(fn);
if isfield(ni,'Variables')
    n = length(ni.Variables);
    for i=1:n
        try
            s.(ni.Variables(i).Name) =
ncread(fn,ni.Variables(i).Name);
        catch
            s.(ni.Variables(i).Name) = h5read(fn,
strcat('/',ni.Variables(i).Name));
        end
    end
end
% Groups
ng = length(ni.Groups);
for g = 1:ng
    n = length(ni.Groups(g).Variables);
    for i=1:n
        s.(ni.Groups(g).Name).(ni.Groups(g).Variables(i).Name) =
ncread(fn,['/' ni.Groups(g).Name '/'
ni.Groups(g).Variables(i).Name]);
    end
end
end
```


Appendix B: CDL files

Common Data form Language (CDL) text files can be generated from product files by running the `ncdump` utility that comes with the NetCDF4 library ("`ncdump -h`"). A CDL file shows the structure of the product file, including global attributes, groups, variables and variable attributes.

NSR CDL:

```
netcdf snpp_l1b_cris_nsr {
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 = 45; // along-track spatial dimension
    xtrack = 30; // cross-track spatial dimension
    fov = 9; // Field-of-view dimension
    wnum_lw = 717; // longwave IR channel number
    wnum_mw = 437; // midwave IR channel number
    wnum_sw = 163; // shortwave IR channel number

// global attributes:
    string :keywords="EARTH SCIENCE > SPECTRAL/ENGINEERING > INFRARED WAVELENGTHS >
INFRARED RADIANCE"; // 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).
    string :Conventions="CF-1.6, ACDD-1.3";
    string :naming_authority="Unassigned"; // In final published products this is
expected to be http://dx.doi.org/; 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'.
    string :history=""; // Requirement against executable that writes the NetCDF. Value
will be appended to and not overwritten.; 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.
    string :source="CrIS instrument telemetry"; // 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'.
    string :processing_level="1B"; // A textual description of the processing (or
quality control) level of the data.
    string :product_name_type_id="L1B_NSR"; // Product name as it appears in
product_name (L1A, L1B, L2, SNO_AIRS_CrIS)
    string :comment=""; // Currently not intended to be used.; Miscellaneous
information about the data or methods used to produce it. Can be empty.
    string :acknowledgment="Support for this research was provided by NASA."; // A
place to acknowledge various types of support for the project that produced this data.
    string :license="Limited to Sounder SIPS affiliates"; // 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.
    string :standard_name_vocabulary="CF Standard Name Table v28"; // 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'.
    string :date_created="Unassigned"; // PGE responsibility; 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.
    string :creator_name="Unassigned"; // The name of the person (or other creator type
specified by the creator_type attribute) principally responsible for creating this data.
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string :creator_email="Unassigned"; // The email address of the person (or other
creator type specified by the creator_type attribute) principally responsible for creating
this data.
string :creator_url="Unassigned"; // The URL of the person (or other creator type
specified by the creator_type attribute) principally responsible for creating this data.
string :institution="Unassigned"; // Processing facility that produced this file
string :project="Sounder SIPS"; // 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'.
string :product_name_project="SNDR"; // The name of the project as it appears in
the file name. 'SNDR' for all Sounder SIPS products, even AIRS products.
string :publisher_name="Unassigned"; // 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.
string :publisher_email="Unassigned"; // 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.
string :publisher_url="Unassigned"; // 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.
string :geospatial_bounds=""; // Will use the POLYGON as shown in the
description. The example is clockwise as viewed from above, but WKT spec at
https://en.wikipedia.org/wiki/Well-known_text says it should be counter-clockwise. We'll go
counterclockwise. The last point must repeat the first point to provide closure. L1A PGE
geolocation fills in and later PGEs copy.; 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))'.
string :geospatial_bounds_crs="EPSG:4326"; // 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'.
float :geospatial_lat_min=9.9692099683868690e+36f; // PGE responsibility;
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.
float :geospatial_lat_max=9.9692099683868690e+36f; // PGE responsibility;
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.
float :geospatial_lon_min=9.9692099683868690e+36f; // PGE responsibility;
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.
float :geospatial_lon_max=9.9692099683868690e+36f; // PGE responsibility;
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, 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).
string :time_coverage_start=""; // We use nominal limits, not the actual timestamp
of the first data point. (seconds always = 00.00"); 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.
string :time_of_first_valid_obs=""; // This is a companion to
time_coverage_start. But where time_coverage_start gives the nominal limit, this gives the
actual timestamp of the first valid observation included in the product.; Describes the time
of the first valid data point in the data set. Use the ISO 8601:2004 date extended format.
string :time_coverage_mid=""; // We use nominal limits, not the actual timestamps
of the first and last data points. (seconds always = 00.00"); 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.

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    string :time_coverage_end=""; // We use nominal limits, not the actual timestamp of
the first data point. (seconds always = 00.00") This value may be 1 second wrong in case of
a leapsecond.; 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.
    string :time_of_last_valid_obs=""; // This is a companion to
time_coverage_end. But where time_coverage_end gives the nominal limit, this gives the
actual timestamp of the last valid observation included in the product. Note that this can
be a few seconds after the nominal end time given in time_coverage_end.;
    string :time_coverage_duration="P0000-00-00T00:06:00"; // This value may
technically be 1 second wrong in cases with leapseconds but the value will not change.;
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.
    string :product_name_duration="m06"; // Product duration as it appears in
product_name (m06 means six minutes)
    string :creator_type="institution"; // 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.
    string :creator_institution="Jet Propulsion Laboratory -- California Institute of
Technology"; // 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.
    string :product_version="v01.00.00"; // product_version is the version assigned to
the build of the overall Sounder SIPS system. It will increment for all PGEs each build,
even if not all PGEs have any changes. Always of the form 'vxx.yy.zz', with 2-digit major,
minor, and revision subfields. (ex 'v01.00.12.'). Major version will correspond to DISC
collection number.; 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.
    string :keywords_vocabulary="GCMD:GCMD Keywords"; // 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 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'.
    string :platform="SUOMI-NPP > Suomi National Polar-orbiting Partnership"; // 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.
    string :platform_vocabulary="GCMD:GCMD Keywords"; // Controlled vocabulary for the
names used in the "platform" attribute.
    string :product_name_platform="SNPP"; // Platform name as it appears in
product_name
    string :instrument="CrIS > Cross-track Infrared Sounder"; // Name of the
contributing instrument(s) or sensor(s) used to create this data set or product. Indicate
controlled vocabulary used in instrument_vocabulary.
    string :instrument_vocabulary="GCMD:GCMD Keywords"; // Controlled vocabulary for
the names used in the "instrument" attribute.
    string :product_name_instr="CRIS"; // Instrument name as it appears in product_name
    string :product_name=""; // PGE responsibility; Canonical fully qualified product
name (official file name)
    string :product_name_variant="std"; // PGE Responsibility ('std' should be the
default); 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.
    string :product_name_version="vxx_xx_xx"; // product_name_version is a simplified
form of product_version that goes into the file name. It substitutes underscores for dots
and excludes the revision subfield. (ex 'v01_00' for distribution; 'v01_00_12' for local).
Note this string will be flowed into the PGEs through the config files in order to provide
control of how the filenames appear across the entire ensemble of data products.; Version
number as it appears in product_name (v01_00_00)
    string :product_name_producer="T"; // PGE Responsibility; Production facility as it
appears in product_name (single character) 'T' is the default, for unofficial local test
products
    string :product_name_timestamp="yymmddhhmmss"; // PGE responsibility; Processing
timestamp as it appears in product_name (yymmddhhmmss)
    string :product_name_extension="nc"; // File extension as it appears in
product_name (typically nc)
    ushort :granule_number=0.0; // PGE responsibility. L1A fills in and later PGEs
copy.; granule number of day (1-240)
    string :product_name_granule_number="g000"; // PGE responsibility. L1A fills in
and later PGEs copy.; zero-padded string for granule number of day (g001-g240)
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    string :gran_id="yyyyymmddThhmm"; // PGE responsibility. L1A fills in and later
PGEs copy.; Unique granule identifier yyyyymmddThhmm of granule start, including year, month,
day, hour, and minute of granule start time
    float :geospatial_lat_mid=9.9692099683868690e+36f; // PGE responsibility. L1A
fills in and later PGEs copy.; granule center latitude
    float :geospatial_lon_mid=9.9692099683868690e+36f; // PGE responsibility. L1A
fills in and later PGEs copy.; granule center longitude
    string :featureType="point"; // should be swath but that is not permitted by the
current version of CF; structure of data in file
    string :data_structure="swath"; // 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.)
    string :cdm_data_type="Swath"; // 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.)
    string :identifier_product_doi_authority="Unassigned"; // probably redundant with
naming_authority but retained for EOSDIS compatibility. Expected to be http://dx.doi.org/ in
final published products.; digital signature source
    string :algorithm_version=""; // It is set by the PGE developers in a config file
or source code they control, so that it can be set by the PGE at run time. If the PGE can
switch different algorithms at runtime, the selected algorithm should be reflected here.; 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: 'CAST 4.2; BB
emis from MIT 2016-04-01')
    string :production_host=""; // PGE responsibility (for science code this string
will be passed in); Identifying information about the host computer for this run. (Output of
linux "uname -a" command.)
    string :format_version="v02.00.11"; // format_version relates to the spreadsheet.
For public products it is of the form 'vxx.yy.zz'. For local runs from a local version of the
spreadsheet it will add the suffix '_Untrusted': 'vxx.yy.zz_Untrusted'. Developers update it
to reflect the level of changes, but always retain the '_Untrusted' suffix.; Format version.
    string :input_file_names=""; // File names only: not path+filename; 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.
    string :input_file_types=""; // These are human-readable tokens agreed by the
team. A downstream process will populate metadata by keying off a list of expected
values. Values include: ATMS_L1A, ATMS_L1B_AliParam, ATMS_L1B_Template; 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.
    string :input_file_dates=""; // Dates shall be formatted according to ISO 8601:
YYYY-MM-DD; 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.
    string :orbitDirection="NA"; // 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.
    string :day_night_flag="NA"; // 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.
    string :AutomaticQualityFlag="Missing"; // Similar to ECS field but ECS field is
per observed parameter and here we give a single value. "Missing" is a special case when
there is no downlinked data. These files are internal placeholders, never visible to the
public.; "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.
    float :qa_pct_data_missing=100.0; // Similar to ECS field QAPercentMissingData but
ECS field is per observed parameter and here we give a single value.; Percentage of expected
observations that are missing.
    float :qa_pct_data_geo=0.0; // Percentage of expected observations that are
successfully geolocated.
    float :qa_pct_data_sci_mode=0.0; // Percentage of expected observations that were
taken while the instrument was in science mode and are successfully geolocated.
    string :qa_no_data="0"; // Processing systems may delete empty files or may
propagate them as placeholders. Empty files should not be seen by the public.; A simple

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indicator of whether this is an "empty" granule with no data from the instrument. "TRUE" or
"FALSE".
    string :title="SNPP CrIS Level-1B NSR"; // a succinct description of what is in the
dataset. (= ECS long name)
    string :summary="The Level-1B CrIS product includes normal spectral resolution data
from the CrIS instrument for one six-minute interval. Data is geolocated and calibrated.";
// A paragraph describing the dataset, analogous to an abstract for a paper.
    string :shortname="SNPPCrISL1BNSR"; // ECS Short Name
    string :product_group="l1b_cris";
    string :id="Unassigned"; // DOI; 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.
    string :identifier_product_doi="Unassigned"; // probably redundant with id but
retained for EOSDIS compatibility; digital signature
    string :metadata_link="http://disc.sci.gsfc.nasa.gov/"; // A URL that gives the
location of more complete metadata. A persistent URL is recommended for this attribute.
    string :references="NASA SNPP Cross Track Infrared Sounder (CrIS) Level 1B Delta
Algorithm Theoretical Basis Document (ATBD) Version 2.0"; // ATBD and design documents
describing processing algorithms. Can be empty.
    string :contributor_name="UW-Madison Space Science and Engineering Center: Hank
Revercomb; UMBC Atmospheric Spectroscopy Laboratory: Larrabee Strow"; // Can be a semicolon-
separated list. contributor_role must then be a parallel semicolon-separated list.; The
names of any individuals or institutions that contributed to the creation of this data.
    string :contributor_role="CrIS L1B Scientist; CrIS L1B Scientist"; // See
contributor_name; The roles of any individuals or institutions that contributed to the
creation of this data.
variables:
    string obs_id(atrack, xtrack);
        string obs_id:units="1";
        string obs_id:long_name="observation id for FOR";
        string obs_id:description="unique observation identifier:
yyyyymmddThhmm.aaSxx. Includes gran_id plus 2-digit along-track index (01-45), scene
identifier (E=earth, H=hot, C=cold) and 2-digit cross-track index (01-30).";
        string obs_id:coverage_content_type="referenceInformation";

    string fov_obs_id(atrack, xtrack, fov);
        string fov_obs_id:units="1";
        string fov_obs_id:long_name="observation id for FOV";
        string fov_obs_id:description="unique observation identifier for FOV:
yyyyymmddThhmm.aaSxx.f . Includes gran_id plus 2-digit along-track index (01-45), scene
identifier (E=earth, H=hot, C=cold) , 2-digit cross-track index (01-30), and 1-digit FOV
number (1-9).";
        string fov_obs_id:coverage_content_type="referenceInformation";

    ubyte instrument_state(atrack, xtrack, fov);
        string instrument_state:units="1";
        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.";
        ubyte instrument_state:FillValue=255ub;
        string instrument_state:coverage_content_type="qualityInformation";
        string instrument_state:flag_meanings="Process Special Erroneous Missing";
        ubyte instrument_state:flag_values=0, 1, 2, 3;

    double obs_time_tai93(atrack, xtrack);
        string obs_time_tai93:units="seconds since 1993-01-01 00:00";
        double obs_time_tai93:valid_range=-2934835217.0, 3376598410.0;
        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";

        double obs_time_tai93:FillValue=9.9692099683868690e+36;
        string obs_time_tai93:coverage_content_type="referenceInformation";
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ushort obs_time_utc(atrack, xtrack, utc_tuple);
    string obs_time_utc:units="1";
    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, millisecc, microsec";
    ushort obs_time_utc:_FillValue= 65535us;
    string obs_time_utc:coverage_content_type="referenceInformation";

float lat(atrack, xtrack, fov);
    string lat:units="degrees_north";
    float lat:valid_range=-90.0, 90.0;
    string lat:long_name="latitude";
    string lat:standard_name="latitude";
    string lat:description="latitude of FOV center";
    float lat:_FillValue=9.9692099683868690e+36f;
    string lat:coverage_content_type="referenceInformation";
    string lat:bounds="lat_bnds";

float lat_geoid(atrack, xtrack, fov);
    string lat_geoid:units="degrees_north";
    float lat_geoid:valid_range=-90.0, 90.0;
    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)";
    float lat_geoid:_FillValue=9.9692099683868690e+36f;
    string lat_geoid:coverage_content_type="referenceInformation";

float lon(atrack, xtrack, fov);
    string lon:units="degrees_east";
    float lon:valid_range=-180.0, 180.0;
    string lon:long_name="longitude";
    string lon:standard_name="longitude";
    string lon:description="longitude of FOV center";
    float lon:_FillValue=9.9692099683868690e+36f;
    string lon:coverage_content_type="referenceInformation";
    string lon:bounds="lon_bnds";

float lon_geoid(atrack, xtrack, fov);
    string lon_geoid:units="degrees_east";
    float lon_geoid:valid_range=-180.0, 180.0;
    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)";
    float lon_geoid:_FillValue=9.9692099683868690e+36f;
    string lon_geoid:coverage_content_type="referenceInformation";

float lat_bnds(atrack, xtrack, fov, fov_poly);
    string lat_bnds:units="degrees_north";
    float lat_bnds:valid_range=-90.0, 90.0;
    string lat_bnds:long_name="FOV boundary latitudes";
    string lat_bnds:description="latitudes of points forming a polygon around the
perimeter of the FOV";
    float lat_bnds:_FillValue=9.9692099683868690e+36f;
    string lat_bnds:coverage_content_type="referenceInformation";

float lon_bnds(atrack, xtrack, fov, fov_poly);
    string lon_bnds:units="degrees_east";
    float lon_bnds:valid_range=-180.0, 180.0;

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        string lon_bnds:long_name="FOV boundary longitudes";
        string lon_bnds:description="longitudes of points forming a polygon around the
perimeter of the FOV";
        float lon_bnds:_FillValue=9.9692099683868690e+36f;
        string lon_bnds:coverage_content_type="referenceInformation";

float land_frac(atrack, xtrack, fov);
string land_frac:units="1";
float land_frac:valid_range=0.0, 1.0;
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";
float land_frac:_FillValue=9.9692099683868690e+36f;
string land_frac:coverage_content_type="referenceInformation";
string land_frac:cell_methods="area: mean (beam-weighted)";

float surf_alt(atrack, xtrack, fov);
string surf_alt:units="m";
string surf_alt:ancillary_variables="surf_alt_sdev";
float surf_alt:valid_range=-500.0, 10000.0;
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";
float surf_alt:_FillValue=9.9692099683868690e+36f;
string surf_alt:coverage_content_type="referenceInformation";
string surf_alt:cell_methods="area: mean (beam-weighted)";

float surf_alt_sdev(atrack, xtrack, fov);
string surf_alt_sdev:units="m";
float surf_alt_sdev:valid_range=0.0, 10000.0;
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";
float surf_alt_sdev:_FillValue=9.9692099683868690e+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";
float sun_glint_lat:valid_range=-90.0, 90.0;
string sun_glint_lat:long_name="sun glint latitude";
string sun_glint_lat:standard_name="latitude";
string sun_glint_lat:coordinates="subsatsat_lon subsatsat_lat";
string sun_glint_lat:description="sun glint spot latitude at
scan_mid_time. Fill for night observations.";
float sun_glint_lat:_FillValue=9.9692099683868690e+36f;
string sun_glint_lat:coverage_content_type="referenceInformation";

float sun_glint_lon(atrack);
string sun_glint_lon:units="degrees_east";
float sun_glint_lon:valid_range=-180.0, 180.0;
string sun_glint_lon:long_name="sun glint longitude";
string sun_glint_lon:standard_name="longitude";
string sun_glint_lon:coordinates="subsatsat_lon subsatsat_lat";
string sun_glint_lon:description="sun glint spot longitude at
scan_mid_time. Fill for night observations.";
float sun_glint_lon:_FillValue=9.9692099683868690e+36f;
string sun_glint_lon:coverage_content_type="referenceInformation";

```

```

float sol_zen(atrack, xtrack, fov);
  string sol_zen:units="degree";
  float sol_zen:valid_range=0.0, 180.0;
  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 FOV";
  float sol_zen:_FillValue=9.9692099683868690e+36f;
  string sol_zen:coverage_content_type="referenceInformation";

float sol_azi(atrack, xtrack, fov);
  string sol_azi:units="degree";
  float sol_azi:valid_range=0.0, 360.0;
  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 FOV
(clockwise from North)";
  float sol_azi:_FillValue=9.9692099683868690e+36f;
  string sol_azi:coverage_content_type="referenceInformation";

float sun_glint_dist(atrack, xtrack, fov);
  string sun_glint_dist:units="m";
  float sun_glint_dist:valid_range=0.0, 30000000.0;
  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 FOV";
  float sun_glint_dist:_FillValue=9.9692099683868690e+36f;
  string sun_glint_dist:coverage_content_type="referenceInformation";

float view_ang(atrack, xtrack, fov);
  string view_ang:units="degree";
  float view_ang:valid_range=0.0, 180.0;
  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";
  float view_ang:_FillValue=9.9692099683868690e+36f;
  string view_ang:coverage_content_type="referenceInformation";

float sat_zen(atrack, xtrack, fov);
  string sat_zen:units="degree";
  float sat_zen:valid_range=0.0, 180.0;
  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 FOV";
  float sat_zen:_FillValue=9.9692099683868690e+36f;
  string sat_zen:coverage_content_type="referenceInformation";

float sat_azi(atrack, xtrack, fov);
  string sat_azi:units="degree";
  float sat_azi:valid_range=0.0, 360.0;
  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 FOV
(clockwise from North)";
  float sat_azi:_FillValue=9.9692099683868690e+36f;
  string sat_azi:coverage_content_type="referenceInformation";

float sat_range(atrack, xtrack, fov);

```


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```
string sat_range:units="m";
    float sat_range:valid_range=1.0e5, 1.0e7;
string sat_range:long_name="satellite range";
string sat_range:coordinates="lon lat";
string sat_range:description="line of sight distance between satellite and FOV
center";
    float sat_range:_FillValue=9.9692099683868690e+36f;
string sat_range:coverage_content_type="referenceInformation";

ubyte asc_flag(atrack);
string asc_flag:units="1";
    ubyte asc_flag:valid_range=0, 1;
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";
    ubyte asc_flag:_FillValue=255ub;
string asc_flag:coverage_content_type="referenceInformation";
string asc_flag:flag_meanings="descending ascending";
    ubyte asc_flag:flag_values=0, 1;

float subsat_lat(atrack); // standard_name platform_latitude is under review for a
future CF version
string subsat_lat:units="degrees_north";
    float subsat_lat:valid_range=-90.0, 90.0;
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";
    float subsat_lat:_FillValue=9.9692099683868690e+36f;
string subsat_lat:coverage_content_type="referenceInformation";

float subsat_lon(atrack); // standard_name platform_longitude is under review for
a future CF version
string subsat_lon:units="degrees_east";
    float subsat_lon:valid_range=-180.0, 180.0;
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";
    float subsat_lon:_FillValue=9.9692099683868690e+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";
double scan_mid_time:valid_range=-2934835217.0, 3376598410.0;
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";
double scan_mid_time:_FillValue=9.9692099683868690e+36f;
string scan_mid_time:coverage_content_type="referenceInformation";

float sat_alt(atrack); // standard_name platform_altitude is under review for a
future CF version
string sat_alt:units="m";
    float sat_alt:valid_range=1.0e5, 1.0e6;
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";
    float sat_alt:_FillValue=9.9692099683868690e+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";
  float sat_pos:_FillValue=9.9692099683868690e+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";
  float sat_vel:_FillValue=9.9692099683868690e+36f;
  string sat_vel:coverage_content_type="referenceInformation";

float sat_att(atrack, attitude);
  string sat_att:units="degree";
  float sat_att:valid_range=-180.0, 180.0;
  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.";
  float sat_att:_FillValue=9.9692099683868690e+36f;
  string sat_att:coverage_content_type="referenceInformation";

float local_solar_time(atrack, xtrack, fov);
  string local_solar_time:units="hours";
  float local_solar_time:valid_range=0.0, 24.0;
  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";
  float local_solar_time:_FillValue=9.9692099683868690e+36f;
  string local_solar_time:coverage_content_type="referenceInformation";

float mean_anom_wrt_equat(atrack);
  string mean_anom_wrt_equat:units="degrees";
  float mean_anom_wrt_equat:valid_range=0.0, 360.0;
  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";
  float mean_anom_wrt_equat:_FillValue=9.9692099683868690e+36f;
  string mean_anom_wrt_equat:coverage_content_type="referenceInformation";

float sat_sol_zen(atrack);
  string sat_sol_zen:units="degrees";
  float sat_sol_zen:valid_range=0.0, 180.0;
  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";
  float sat_sol_zen:_FillValue=9.9692099683868690e+36f;
  string sat_sol_zen:coverage_content_type="referenceInformation";

float sat_sol_azi(atrack);
  string sat_sol_azi:units="degrees";

```

```

float sat_sol_azi:valid_range=0.0, 360.0;
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)";
float sat_sol_azi: FillValue=9.9692099683868690e+36f;
string sat_sol_azi:coverage_content_type="referenceInformation";

float asc_node_lon;
string asc_node_lon:units="degrees_east";
float asc_node_lon:valid_range=-180.0, 180.0;
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.";
float asc_node_lon: FillValue=9.9692099683868690e+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";
double asc_node_tai93:valid_range=-2934835217.0, 3376598410.0;
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.";
double asc_node_tai93: FillValue=9.9692099683868690e+36f;
string asc_node_tai93:coverage_content_type="referenceInformation";

float asc_node_local_solar_time;
string asc_node_local_solar_time:units="hours";
float asc_node_local_solar_time:valid_range=0.0, 24.0;
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";
float asc_node_local_solar_time: FillValue=9.9692099683868690e+36f;
string asc_node_local_solar_time:coverage_content_type="referenceInformation";

float solar_beta_angle;
string solar_beta_angle:units="degrees";
float solar_beta_angle:valid_range=-90.0, 90.0;
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.";
float solar_beta_angle: FillValue=9.9692099683868690e+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 rad_lw(atrack, xtrack, fov, wnum_lw);
  string rad_lw:units="mW/(m2 sr cm-1)";
  string rad_lw:ancillary_variables="rad_lw_qc";
  string rad_lw:long_name="longwave real spectral radiance";
  string rad_lw:standard_name="toa_outgoing_radiance_per_unit_wavenumber";
  string rad_lw:coordinates="lon lat";
  string rad_lw:description="longwave real spectral radiance";
  float rad_lw:_FillValue=9.9692099683868690e+36f;
  string rad_lw:coverage_content_type="physicalMeasurement";

byte rad_lw_qc(atrack, xtrack, fov);
  string rad_lw_qc:units="1";
  byte rad_lw_qc:valid_range=0, 2;
  string rad_lw_qc:long_name="rad_lw QC";
  string rad_lw_qc:standard_name="toa_outgoing_radiance_per_unit_wavenumber
status_flag";
  string rad_lw_qc:coordinates="lon lat";
  string rad_lw_qc:description="rad_lw QC flag";
  byte rad_lw_qc:_FillValue=-1b;
  string rad_lw_qc:coverage_content_type="qualityInformation";
  string rad_lw_qc:flag_meanings="Best Good Do_Not_Use";
  byte rad_lw_qc:flag_values=0, 1, 2;

float rad_mw(atrack, xtrack, fov, wnum_mw);
  string rad_mw:units="mW/(m2 sr cm-1)";
  string rad_mw:ancillary_variables="rad_mw_qc";
  string rad_mw:long_name="midwave real spectral radiance";
  string rad_mw:standard_name="toa_outgoing_radiance_per_unit_wavenumber";
  string rad_mw:coordinates="lon lat";
  string rad_mw:description="midwave real spectral radiance";
  float rad_mw:_FillValue=9.9692099683868690e+36f;
  string rad_mw:coverage_content_type="physicalMeasurement";

byte rad_mw_qc(atrack, xtrack, fov);
  string rad_mw_qc:units="1";
  byte rad_mw_qc:valid_range=0, 2;
  string rad_mw_qc:long_name="rad_mw QC";
  string rad_mw_qc:standard_name="toa_outgoing_radiance_per_unit_wavenumber
status_flag";
  string rad_mw_qc:coordinates="lon lat";
  string rad_mw_qc:description="rad_mw QC flag";
  byte rad_mw_qc:_FillValue=-1b;
  string rad_mw_qc:coverage_content_type="qualityInformation";
  string rad_mw_qc:flag_meanings="Best Good Do_Not_Use";
  byte rad_mw_qc:flag_values=0, 1, 2;

float rad_sw(atrack, xtrack, fov, wnum_sw);
  string rad_sw:units="mW/(m2 sr cm-1)";
  string rad_sw:ancillary_variables="rad_sw_qc";
  string rad_sw:long_name="shortwave real spectral radiance";
  string rad_sw:standard_name="toa_outgoing_radiance_per_unit_wavenumber";
  string rad_sw:coordinates="lon lat";
  string rad_sw:description="shortwave real spectral radiance";
  float rad_sw:_FillValue=9.9692099683868690e+36f;
  string rad_sw:coverage_content_type="physicalMeasurement";

byte rad_sw_qc(atrack, xtrack, fov);
  string rad_sw_qc:units="1";
  byte rad_sw_qc:valid_range=0, 2;
  string rad_sw_qc:long_name="rad_sw QC";
  string rad_sw_qc:standard_name="toa_outgoing_radiance_per_unit_wavenumber
status_flag";

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string rad_sw_qc:coordinates="lon lat";
string rad_sw_qc:description="rad_sw QC flag";
    byte rad_sw_qc:_FillValue=-1b;
string rad_sw_qc:coverage_content_type="qualityInformation";
string rad_sw_qc:flag_meanings="Best Good Do_Not_Use";
    byte rad_sw_qc:flag_values=0, 1, 2;

int cal_qualflag(atrack, xtrack, fov);
    string cal_qualflag:units="1";
    string cal_qualflag:long_name="L1B quality flags";
    string cal_qualflag:coordinates="lon lat";
    string cal_qualflag:description="per-observation L1B product quality";
    int cal_qualflag:_FillValue=-2147483647;
    string cal_qualflag:coverage_content_type="qualityInformation";
    string cal_qualflag:flag_meanings="geo_quality_invalid inv_instrument_temp
excess_temp_drift fce_detected fce_correction_fail neon_cal_quality_flag isa_degraded_flag
lla_bit_trim_mismatch lla_eight_sec_missing";
    int cal_qualflag:flag_masks=1, 2, 4, 8, 16, 32, 64,
    128, 256;
    int cal_qualflag:flag_values=1, 2, 4, 8, 16, 32, 64,
    128, 256;

int cal_lw_qualflag(atrack, xtrack, fov);
    string cal_lw_qualflag:units="1";
    string cal_lw_qualflag:long_name="LW quality flags";
    string cal_lw_qualflag:coordinates="lon lat";
    string cal_lw_qualflag:description="per-observation L1B LW product quality";
    int cal_lw_qualflag:_FillValue=-2147483647;
    string cal_lw_qualflag:coverage_content_type="qualityInformation";
    string cal_lw_qualflag:flag_meanings="quality_degraded quality_invalid
rad_cal_qual_degraded rad_cal_qual_invalid spectral_cal_qual_degraded
spectral_cal_qual_invalid imag_rad_anomaly lunar_intrusion lla_missing_es";
    int cal_lw_qualflag:flag_masks=3, 3, 12, 12, 48, 48, 64,
    128, 256;
    int cal_lw_qualflag:flag_values=1, 2, 4, 8, 16, 32,
    64, 128, 256;

int cal_mw_qualflag(atrack, xtrack, fov);
    string cal_mw_qualflag:units="1";
    string cal_mw_qualflag:long_name="MW quality flags";
    string cal_mw_qualflag:coordinates="lon lat";
    string cal_mw_qualflag:description="per-observation L1B MW product quality";
    int cal_mw_qualflag:_FillValue=-2147483647;
    string cal_mw_qualflag:coverage_content_type="qualityInformation";
    string cal_mw_qualflag:flag_meanings="quality_degraded quality_invalid
rad_cal_qual_degraded rad_cal_qual_invalid spectral_cal_qual_degraded
spectral_cal_qual_invalid imag_rad_anomaly lunar_intrusion lla_missing_es";
    int cal_mw_qualflag:flag_masks=3, 3, 12, 12, 48, 48, 64,
    128, 256;
    int cal_mw_qualflag:flag_values=1, 2, 4, 8, 16, 32,
    64, 128, 256;

int cal_sw_qualflag(atrack, xtrack, fov);
    string cal_sw_qualflag:units="1";
    string cal_sw_qualflag:long_name="SW quality flags";
    string cal_sw_qualflag:coordinates="lon lat";
    string cal_sw_qualflag:description="per-observation L1B SW product quality";
    int cal_sw_qualflag:_FillValue=-2147483647;
    string cal_sw_qualflag:coverage_content_type="qualityInformation";
    string cal_sw_qualflag:flag_meanings="quality_degraded quality_invalid
rad_cal_qual_degraded rad_cal_qual_invalid spectral_cal_qual_degraded
spectral_cal_qual_invalid imag_rad_anomaly lunar_intrusion lla_missing_es";
    int cal_sw_qualflag:flag_masks=3, 3, 12, 12, 48, 48, 64,
    128, 256;
    int cal_sw_qualflag:flag_values=1, 2, 4, 8, 16, 32,
    64, 128, 256;

```

```

float nedn_lw(fov, wnum_lw);
  string nedn_lw:units="mW/(m2 sr cm-1)";
  string nedn_lw:long_name="longwave noise equivalent differential radiance";
  string nedn_lw:description="longwave noise equivalent differential radiance";
  float nedn_lw:_FillValue=9.9692099683868690e+36f;
  string nedn_lw:coverage_content_type="qualityInformation";

float nedn_mw(fov, wnum_mw);
  string nedn_mw:units="mW/(m2 sr cm-1)";
  string nedn_mw:long_name="midwave noise equivalent differential radiance";
  string nedn_mw:description="midwave noise equivalent differential radiance";
  float nedn_mw:_FillValue=9.9692099683868690e+36f;
  string nedn_mw:coverage_content_type="qualityInformation";

float nedn_sw(fov, wnum_sw);
  string nedn_sw:units="mW/(m2 sr cm-1)";
  string nedn_sw:long_name="shortwave noise equivalent differential radiance";
  string nedn_sw:description="shortwave noise equivalent differential radiance";
  float nedn_sw:_FillValue=9.9692099683868690e+36f;
  string nedn_sw:coverage_content_type="qualityInformation";

ubyte scan_sweep_dir(xtrack);
  string scan_sweep_dir:units="1";
  ubyte scan_sweep_dir:valid_range=0, 1;
  string scan_sweep_dir:long_name="sweep direction of FOVs within a scan";
  string scan_sweep_dir:description="sweep direction of FOVs within a scan";
  ubyte scan_sweep_dir:_FillValue=255ub;
  string scan_sweep_dir:coverage_content_type="auxiliaryInformation";
  string scan_sweep_dir:flag_meanings="forward reverse";
  ubyte scan_sweep_dir:flag_values=0, 1;

ubyte for_num(xtrack);
  string for_num:units="1";
  ubyte for_num:valid_range=1, 30;
  string for_num:long_name="field of regard number";
  string for_num:description="field of regard number";
  ubyte for_num:_FillValue=255ub;
  string for_num:coverage_content_type="auxiliaryInformation";

ubyte fov_num(fov);
  string fov_num:units="1";
  ubyte fov_num:valid_range=1, 9;
  string fov_num:long_name="field of view number";
  string fov_num:description="field of view number";
  ubyte fov_num:_FillValue=255ub;
  string fov_num:coverage_content_type="auxiliaryInformation";

double wnum_lw(wnum_lw);
  string wnum_lw:units="cm-1";
  double wnum_lw:valid_range=648.75, 1096.25;
  string wnum_lw:long_name="longwave wavenumber";
  string wnum_lw:standard_name="sensor_band_central_radiation_wavenumber";
  string wnum_lw:description="longwave wavenumber";
  double wnum_lw:_FillValue=9.9692099683868690e+36;
  string wnum_lw:coverage_content_type="auxiliaryInformation";

double wnum_mw(wnum_mw);
  string wnum_mw:units="cm-1";
  double wnum_mw:valid_range=1207.5, 1752.5;

```

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```

string wnum_mw:long_name="midwave wavenumber";
string wnum_mw:standard_name="sensor_band_central_radiation_wavenumber";
string wnum_mw:description="midwave wavenumber";
double wnum_mw:FillValue=9.9692099683868690e+36;
string wnum_mw:coverage_content_type="auxiliaryInformation";

double wnum_sw(wnum_sw);
string wnum_sw:units="cm-1";
double wnum_sw:valid_range=2150.0, 2555.0;
string wnum_sw:long_name="shortwave wavenumber";
string wnum_sw:standard_name="sensor_band_central_radiation_wavenumber";
string wnum_sw:description="shortwave wavenumber";
double wnum_sw:FillValue=9.9692099683868690e+36;
string wnum_sw:coverage_content_type="auxiliaryInformation";

data:
attitude_lbl="Roll", "Pitch", "Yaw";
spatial_lbl="X", "Y", "Z";
utc_tuple_lbl="year", "month", "day", "hour", "minute",
"second", "millisecond", "microsecond";
scan_sweep_dir=0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0,
0.0,
1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0,
0.0, 1.0;
for_num=1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0,
26.0,
14.0, 15.0, 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0, 25.0,
27.0, 28.0, 29.0, 30.0;
fov_num=1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0;

group: aux {
variables:
int geo_qualflag(atrack, xtrack, fov);
string geo_qualflag:units="1";
string geo_qualflag:long_name="geolocation quality flags";
string geo_qualflag:coordinates="lon lat";
string geo_qualflag:description="per-observation L1B geolocation quality";
int geo_qualflag:FillValue=-2147483647;
string geo_qualflag:coverage_content_type="qualityInformation";
string geo_qualflag:flag_meanings="obs_time_missing servo_error_missing
scd_gap_sm scd_gap_md scd_gap_lg stale utcpole";
int geo_qualflag:flag_masks=1, 2, 12, 12, 12, 16;
int geo_qualflag:flag_values=1, 2, 4, 8, 12, 16;

float rad_imag_lw(atrack, xtrack, fov, wnum_lw);
string rad_imag_lw:units="mW/(m2 sr cm-1)";
string rad_imag_lw:long_name="longwave imaginary spectral radiance";
string
rad_imag_lw:standard_name="toa_outgoing_radiance_per_unit_wavenumber";
string rad_imag_lw:coordinates="lon lat";
string rad_imag_lw:description="longwave imaginary spectral radiance";
float rad_imag_lw:FillValue=9.9692099683868690e+36f;
string rad_imag_lw:coverage_content_type="qualityInformation";

float rad_imag_mw(atrack, xtrack, fov, wnum_mw);
string rad_imag_mw:units="mW/(m2 sr cm-1)";
string rad_imag_mw:long_name="midwave imaginary spectral radiance";
string
rad_imag_mw:standard_name="toa_outgoing_radiance_per_unit_wavenumber";
string rad_imag_mw:coordinates="lon lat";
string rad_imag_mw:description="midwave imaginary spectral radiance";
float rad_imag_mw:FillValue=9.9692099683868690e+36f;
string rad_imag_mw:coverage_content_type="qualityInformation";

```

```

float rad_imag_sw(atrack, xtrack, fov, wnum_sw);
  string rad_imag_sw:units="mW/(m2 sr cm-1)";
  string rad_imag_sw:long_name="shortwave imaginary spectral radiance";
  string
rad_imag_sw:standard_name="toa_outgoing_radiance_per_unit_wavenumber";
  string rad_imag_sw:coordinates="lon lat";
  string rad_imag_sw:description="shortwave imaginary spectral radiance";
  float rad_imag_sw: FillValue=9.9692099683868690e+36f;
  string rad_imag_sw:coverage_content_type="qualityInformation";

double max_opd_lw;
  string max_opd_lw:units="cm";
  string max_opd_lw:long_name="maximum longwave optical path difference";
  string max_opd_lw:description="maximum longwave optical path difference";
  double max_opd_lw: FillValue=9.9692099683868690e+36;
  string max_opd_lw:coverage_content_type="qualityInformation";

double max_opd_mw;
  string max_opd_mw:units="cm";
  string max_opd_mw:long_name="maximum midwave optical path difference";
  string max_opd_mw:description="maximum midwave optical path difference";
  double max_opd_mw: FillValue=9.9692099683868690e+36;
  string max_opd_mw:coverage_content_type="qualityInformation";

double max_opd_sw;
  string max_opd_sw:units="cm";
  string max_opd_sw:long_name="maximum shortwave optical path difference";
  string max_opd_sw:description="maximum shortwave optical path difference";
  double max_opd_sw: FillValue=9.9692099683868690e+36;
  string max_opd_sw:coverage_content_type="qualityInformation";

short spectral_fold_point_lw;
  string spectral_fold_point_lw:units="1";
  string spectral_fold_point_lw:long_name="longwave spectral folding index";
  string spectral_fold_point_lw:description="one-based index for unfolding
uncalibrated longwave spectrum into ascending wavenumbers";
  short spectral_fold_point_lw: FillValue=-32767s;
  string
spectral_fold_point_lw:coverage_content_type="auxiliaryInformation";

short spectral_fold_point_mw;
  string spectral_fold_point_mw:units="1";
  string spectral_fold_point_mw:long_name="midwave spectral folding index";
  string spectral_fold_point_mw:description="one-based index for unfolding
uncalibrated midwave spectrum into ascending wavenumbers";
  short spectral_fold_point_mw: FillValue=-32767s;
  string
spectral_fold_point_mw:coverage_content_type="auxiliaryInformation";

short spectral_fold_point_sw;
  string spectral_fold_point_sw:units="1";
  string spectral_fold_point_sw:long_name="shortwave spectral folding
index";
  string spectral_fold_point_sw:description="one-based index for unfolding
uncalibrated shortwave spectrum into ascending wavenumbers";
  short spectral_fold_point_sw: FillValue=-32767s;
  string
spectral_fold_point_sw:coverage_content_type="auxiliaryInformation";

double measured_laser_wlen;
  string measured_laser_wlen:units="nm";
  double measured_laser_wlen:valid_range=695.0, 850.0;

```



```

wavelengths";
    string measured_laser_wlen:long_name="measured metrology laser half-
wavelengths";
    string measured_laser_wlen:description="measured metrology laser half-
wavelengths";
    double measured_laser_wlen:_FillValue=9.9692099683868690e+36;
    string measured_laser_wlen:coverage_content_type="qualityInformation";

    double smoothed_laser_wlen;
    string smoothed_laser_wlen:units="nm";
    string smoothed_laser_wlen:long_name="smoothed metrology laser half-
wavelengths";
    string smoothed_laser_wlen:description="smoothed metrology laser half-
wavelengths";
    double smoothed_laser_wlen:_FillValue=9.9692099683868690e+36;
    string smoothed_laser_wlen:coverage_content_type="qualityInformation";

    double smoothed_neon_wlen;
    string smoothed_neon_wlen:units="nm";
    string smoothed_neon_wlen:long_name="smoothed neon laser half-
wavelengths";
    string smoothed_neon_wlen:description="smoothed neon laser half-
wavelengths";
    double smoothed_neon_wlen:_FillValue=9.9692099683868690e+36;
    string smoothed_neon_wlen:coverage_content_type="qualityInformation";

    double neon_wlen;
    string neon_wlen:units="nm";
    string neon_wlen:long_name="neon laser half-wavelengths";
    string neon_wlen:description="neon laser half-wavelengths";
    double neon_wlen:_FillValue=9.9692099683868690e+36;
    string neon_wlen:coverage_content_type="qualityInformation";

    } // aux
} // snpp_llb_cris_nsr

```

FSR CDL:

```

netcdf snpp_llb_cris_fsr {
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 = 45; // along-track spatial dimension
    xtrack = 30; // cross-track spatial dimension
    fov = 9; // Field-of-view dimension
    wnum_lw = 717; // longwave IR channel number
    wnum_mw = 869; // midwave IR channel number
    wnum_sw = 637; // shortwave IR channel number

// global attributes:
    string :keywords="EARTH SCIENCE > SPECTRAL/ENGINEERING > INFRARED WAVELENGTHS >
INFRARED RADIANCE"; // 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).
    string :Conventions="CF-1.6, ACDD-1.3";
    string :naming_authority="Unassigned"; // In final published products this is
expected to be http://dx.doi.org/; 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'.

```

```

    string :history=""; // Requirement against executable that writes the NetCDF. Value
will be appended to and not overwritten.; 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.
    string :source="CrIS instrument telemetry"; // 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'.
    string :processing_level="1B"; // A textual description of the processing (or
quality control) level of the data.
    string :product_name_type_id="L1B"; // Product name as it appears in product_name
(L1A, L1B, L2, SNO_AIRS_CrIS)
    string :comment=""; // Currently not intended to be used.; Miscellaneous
information about the data or methods used to produce it. Can be empty.
    string :acknowledgment="Support for this research was provided by NASA."; // A
place to acknowledge various types of support for the project that produced this data.
    string :license="Limited to Sounder SIPS affiliates"; // 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.
    string :standard_name_vocabulary="CF Standard Name Table v28"; // 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'.
    string :date_created="Unassigned"; // PGE responsibility; 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.
    string :creator_name="Unassigned"; // The name of the person (or other creator type
specified by the creator_type attribute) principally responsible for creating this data.
    string :creator_email="Unassigned"; // The email address of the person (or other
creator type specified by the creator_type attribute) principally responsible for creating
this data.
    string :creator_url="Unassigned"; // The URL of the person (or other creator type
specified by the creator_type attribute) principally responsible for creating this data.
    string :institution="Unassigned"; // Processing facility that produced this file
    string :project="Sounder SIPS"; // 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'.
    string :product_name_project="SNDR"; // The name of the project as it appears in
the file name. 'SNDR' for all Sounder SIPS products, even AIRS products.
    string :publisher_name="Unassigned"; // 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.
    string :publisher_email="Unassigned"; // 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.
    string :publisher_url="Unassigned"; // 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.
    string :geospatial_bounds=""; // Will use the POLYGON as shown in the
description. The example is clockwise as viewed from above, but WKT spec at
https://en.wikipedia.org/wiki/Well-known\_text says it should be counter-clockwise. We'll go
counterclockwise. The last point must repeat the first point to provide closure. L1A PGE
geolocation fills in and later PGEs copy.; 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))'.
    string :geospatial_bounds_crs="EPSG:4326"; // 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

```

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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'.

```
float :geospatial_lat_min=9.9692099683868690e+36f; // PGE responsibility;
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.
float :geospatial_lat_max=9.9692099683868690e+36f; // PGE responsibility;
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.
float :geospatial_lon_min=9.9692099683868690e+36f; // PGE responsibility;
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.
float :geospatial_lon_max=9.9692099683868690e+36f; // PGE responsibility;
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, 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).
string :time_coverage_start=""; // We use nominal limits, not the actual timestamp
of the first data point. (seconds always = 00.00"); 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.
string :time_of_first_valid_obs=""; // This is a companion to
time_coverage_start. But where time_coverage_start gives the nominal limit, this gives the
actual timestamp of the first valid observation included in the product.; Describes the time
of the first valid data point in the data set. Use the ISO 8601:2004 date extended format.
string :time_coverage_mid=""; // We use nominal limits, not the actual timestamps
of the first and last data points. (seconds always = 00.00"); 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.
string :time_coverage_end=""; // We use nominal limits, not the actual timestamp of
the first data point. (seconds always = 00.00") This value may be 1 second wrong in case of
a leapsecond.; 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.
string :time_of_last_valid_obs=""; // This is a companion to
time_coverage_end. But where time_coverage_end gives the nominal limit, this gives the
actual timestamp of the last valid observation included in the product. Note that this can
be a few seconds after the nominal end time given in time_coverage_end.;
string :time_coverage_duration="P0000-00-00T00:06:00"; // This value may
technically be 1 second wrong in cases with leapseconds but the value will not change.;
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.
string :product_name_duration="m06"; // Product duration as it appears in
product_name (m06 means six minutes)
string :creator_type="institution"; // 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.
string :creator_institution="Jet Propulsion Laboratory -- California Institute of
Technology"; // 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.
string :product_version="v01.00.00"; // product_version is the version assigned to
the build of the overall Sounder SIPS system. It will increment for all PGEs each build,
even if not all PGEs have any changes. Always of the form 'vxx.yy.zz', with 2-digit major,
minor, and revision subfields. (ex 'v01.00.12.'). Major version will correspond to DISC
collection number.; 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.
string :keywords_vocabulary="GCMD:GCMD Keywords"; // 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 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'.
string :platform="SUOMI-NPP > Suomi National Polar-orbiting Partnership"; // 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.
```

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```
    string :platform_vocabulary="GCMD:GCMD Keywords"; // Controlled vocabulary for the
names used in the "platform" attribute.
    string :product_name_platform="SNPP"; // Platform name as it appears in
product_name
    string :instrument="CrIS > Cross-track Infrared Sounder"; // Name of the
contributing instrument(s) or sensor(s) used to create this data set or product. Indicate
controlled vocabulary used in instrument_vocabulary.
    string :instrument_vocabulary="GCMD:GCMD Keywords"; // Controlled vocabulary for
the names used in the "instrument" attribute.
    string :product_name_instr="CRIS"; // Instrument name as it appears in product_name
    string :product_name=""; // PGE responsibility; Canonical fully qualified product
name (official file name)
    string :product_name_variant="std"; // PGE Responsibility ('std' should be the
default); 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.
    string :product_name_version="vxx_xx_xx"; // product_name_version is a simplified
form of product_version that goes into the file name. It substitutes underscores for dots
and excludes the revision subfield. (ex 'v01_00' for distribution; 'v01_00_12' for local).
Note this string will be flowed into the PGEs through the config files in order to provide
control of how the filenames appear across the entire ensemble of data products.; Version
number as it appears in product_name (v01_00_00)
    string :product_name_producer="T"; // PGE Responsibility; Production facility as it
appears in product_name (single character) 'T' is the default, for unofficial local test
products
    string :product_name_timestamp="yymmddhhmmss"; // PGE responsibility; Processing
timestamp as it appears in product_name (yymmddhhmmss)
    string :product_name_extension="nc"; // File extension as it appears in
product_name (typically nc)
    ushort :granule_number=0.0; // PGE responsibility. L1A fills in and later PGEs
copy.; granule number of day (1-240)
    string :product_name_granule_number="g000"; // PGE responsibility. L1A fills in
and later PGEs copy.; zero-padded string for granule number of day (g001-g240)
    string :gran_id="yyyymmddThhmm"; // PGE responsibility. L1A fills in and later
PGEs copy.; Unique granule identifier yyyymmddThhmm of granule start, including year, month,
day, hour, and minute of granule start time
    float :geospatial_lat_mid=9.9692099683868690e+36f; // PGE responsibility. L1A
fills in and later PGEs copy.; granule center latitude
    float :geospatial_lon_mid=9.9692099683868690e+36f; // PGE responsibility. L1A
fills in and later PGEs copy.; granule center longitude
    string :featureType="point"; // should be swath but that is not permitted by the
current version of CF; structure of data in file
    string :data_structure="swath"; // 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.)
    string :cdm_data_type="Swath"; // 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.)
    string :identifier_product_doi_authority="Unassigned"; // probably redundant with
naming_authority but retained for EOSDIS compatibility. Expected to be http://dx.doi.org/ in
final published products.; digital signature source
    string :algorithm_version=""; // It is set by the PGE developers in a config file
or source code they control, so that it can be set by the PGE at run time. If the PGE can
switch different algorithms at runtime, the selected algorithm should be reflected here.; 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: 'CAST 4.2; BB
emis from MIT 2016-04-01')
    string :production_host=""; // PGE responsibility (for science code this string
will be passed in); Identifying information about the host computer for this run. (Output of
linux "uname -a" command.)
    string :format_version="v02.00.11"; // format_version relates to the spreadsheet.
For public products it is of the form 'vxx.yy.zz'. For local runs from a local version of the
spreadsheet it will add the suffix '_Untrusted': 'vxx.yy.zz_Untrusted'. Developers update it
to reflect the level of changes, but always retain the '_Untrusted' suffix.; Format version.
    string :input_file_names=""; // File names only: not path+filename; 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.
    string :input_file_types=""; // These are human-readable tokens agreed by the
team. A downstream process will populate metadata by keying off a list of expected
values. Values include: ATMS_L1A, ATMS_L1B_AliParam, ATMS_L1B_Template; Semicolon-separated
```

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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.

```
string :input_file_dates=""; // Dates shall be formatted according to ISO 8601:
YYYY-MM-DD; 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.
string :orbitDirection="NA"; // 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.
string :day_night_flag="NA"; // 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.
string :AutomaticQualityFlag="Missing"; // Similar to ECS field but ECS field is
per observed parameter and here we give a single value. "Missing" is a special case when
there is no downlinked data. These files are internal placeholders, never visible to the
public.; "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.
float :qa_pct_data_missing=100.0; // Similar to ECS field QAPercentMissingData but
ECS field is per observed parameter and here we give a single value.; Percentage of expected
observations that are missing.
float :qa_pct_data_geo=0.0; // Percentage of expected observations that are
successfully geolocated.
float :qa_pct_data_sci_mode=0.0; // Percentage of expected observations that were
taken while the instrument was in science mode and are successfully geolocated.
string :qa_no_data="0"; // Processing systems may delete empty files or may
propagate them as placeholders. Empty files should not be seen by the public.; A simple
indicator of whether this is an "empty" granule with no data from the instrument. "TRUE" or
"FALSE".
string :title="SNPP CrIS Level-1B FSR"; // a succinct description of what is in the
dataset. (= ECS long name)
string :summary="The Level-1B CrIS product includes normal spectral resolution data
from the CrIS instrument for one six-minute interval. Data is geolocated and calibrated.";
// A paragraph describing the dataset, analogous to an abstract for a paper.
string :shortname="SNPPCrISL1B"; // ECS Short Name
string :product_group="l1b cris";
string :id="Unassigned"; // DOI; 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.
string :identifier_product_doi="Unassigned"; // probably redundant with id but
retained for EOSDIS compatibility; digital signature
string :metadata_link="http://disc.sci.gsfc.nasa.gov/"; // A URL that gives the
location of more complete metadata. A persistent URL is recommended for this attribute.
string :references="NASA SNPP Cross Track Infrared Sounder (CrIS) Level 1B Delta
Algorithm Theoretical Basis Document (ATBD) Version 2.0"; // ATDB and design documents
describing processing algorithms. Can be empty.
string :contributor_name="UW-Madison Space Science and Engineering Center: Hank
Revercomb; UMBC Atmospheric Spectroscopy Laboratory: Larrabee Strow"; // Can be a semicolon-
separated list. contributor_role must then be a parallel semicolon-separated list.; The
names of any individuals or institutions that contributed to the creation of this data.
string :contributor_role="CrIS L1B Scientist; CrIS L1B Scientist"; // See
contributor_name; The roles of any individuals or institutions that contributed to the
creation of this data.
variables:
string obs_id(atrack, xtrack);
string obs_id:units="1";
string obs_id:long_name="observation id for FOR";
string obs_id:description="unique observation identifier:
yyyyymmddThhmm.aaSxx. Includes gran_id plus 2-digit along-track index (01-45), scene
identifier (E=earth, H=hot, C=cold) and 2-digit cross-track index (01-30).";
string obs_id:coverage_content_type="referenceInformation";

string fov_obs_id(atrack, xtrack, fov);
string fov_obs_id:units="1";
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        string fov_obs_id:long_name="observation id for FOV";
        string fov_obs_id:description="unique observation identifier for FOV:
yyyyymmddThhmm.aaSxx.f . Includes gran_id plus 2-digit along-track index (01-45), scene
identifier (E=earth, H=hot, C=cold) , 2-digit cross-track index (01-30), and 1-digit FOV
number (1-9).";
        string fov_obs_id:coverage_content_type="referenceInformation";

        ubyte instrument_state(atrack, xtrack, fov);
        string instrument_state:units="1";
        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.";
        ubyte instrument_state:_FillValue=255ub;
        string instrument_state:coverage_content_type="qualityInformation";
        string instrument_state:flag_meanings="Process Special Erroneous Missing";
        ubyte instrument_state:flag_values=0, 1, 2, 3;

        double obs_time_tai93(atrack, xtrack);
        string obs_time_tai93:units="seconds since 1993-01-01 00:00";
        double obs_time_tai93:valid_range=-2934835217.0, 3376598410.0;
        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";
        double obs_time_tai93:_FillValue=9.9692099683868690e+36;
        string obs_time_tai93:coverage_content_type="referenceInformation";

        ushort obs_time_utc(atrack, xtrack, utc_tuple);
        string obs_time_utc:units="1";
        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";
        ushort obs_time_utc:_FillValue= 65535us;
        string obs_time_utc:coverage_content_type="referenceInformation";

        float lat(atrack, xtrack, fov);
        string lat:units="degrees_north";
        float lat:valid_range=-90.0, 90.0;
        string lat:long_name="latitude";
        string lat:standard_name="latitude";
        string lat:description="latitude of FOV center";
        float lat:_FillValue=9.9692099683868690e+36f;
        string lat:coverage_content_type="referenceInformation";
        string lat:bounds="lat_bnds";

        float lat_geoid(atrack, xtrack, fov);
        string lat_geoid:units="degrees_north";
        float lat_geoid:valid_range=-90.0, 90.0;
        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)";
        float lat_geoid:_FillValue=9.9692099683868690e+36f;
        string lat_geoid:coverage_content_type="referenceInformation";

        float lon(atrack, xtrack, fov);
        string lon:units="degrees_east";
        float lon:valid_range=-180.0, 180.0;
        string lon:long_name="longitude";
    
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string lon:standard_name="longitude";
string lon:description="longitude of FOV center";
float lon:_FillValue=9.9692099683868690e+36f;
string lon:coverage_content_type="referenceInformation";
string lon:bounds="lon_bnds";

float lon_geoid(atrack, xtrack, fov);
string lon_geoid:units="degrees_east";
float lon_geoid:valid_range=-180.0, 180.0;
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)";
float lon_geoid:_FillValue=9.9692099683868690e+36f;
string lon_geoid:coverage_content_type="referenceInformation";

float lat_bnds(atrack, xtrack, fov, fov_poly);
string lat_bnds:units="degrees_north";
float lat_bnds:valid_range=-90.0, 90.0;
string lat_bnds:long_name="FOV boundary latitudes";
string lat_bnds:description="latitudes of points forming a polygon around the
perimeter of the FOV";
float lat_bnds:_FillValue=9.9692099683868690e+36f;
string lat_bnds:coverage_content_type="referenceInformation";

float lon_bnds(atrack, xtrack, fov, fov_poly);
string lon_bnds:units="degrees_east";
float lon_bnds:valid_range=-180.0, 180.0;
string lon_bnds:long_name="FOV boundary longitudes";
string lon_bnds:description="longitudes of points forming a polygon around the
perimeter of the FOV";
float lon_bnds:_FillValue=9.9692099683868690e+36f;
string lon_bnds:coverage_content_type="referenceInformation";

float land_frac(atrack, xtrack, fov);
string land_frac:units="1";
float land_frac:valid_range=0.0, 1.0;
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";
float land_frac:_FillValue=9.9692099683868690e+36f;
string land_frac:coverage_content_type="referenceInformation";
string land_frac:cell_methods="area: mean (beam-weighted)";

float surf_alt(atrack, xtrack, fov);
string surf_alt:units="m";
string surf_alt:ancillary_variables="surf_alt_sdev";
float surf_alt:valid_range=-500.0, 10000.0;
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";
float surf_alt:_FillValue=9.9692099683868690e+36f;
string surf_alt:coverage_content_type="referenceInformation";
string surf_alt:cell_methods="area: mean (beam-weighted)";

float surf_alt_sdev(atrack, xtrack, fov);
string surf_alt_sdev:units="m";
float surf_alt_sdev:valid_range=0.0, 10000.0;
string surf_alt_sdev:long_name="surface altitude standard deviation";
string surf_alt_sdev:coordinates="lon lat";

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the FOV";
    string surf_alt_sdev:description="standard deviation of surface altitude within
    float surf_alt_sdev:_FillValue=9.9692099683868690e+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";
    float sun_glint_lat:valid_range=-90.0, 90.0;
    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.";
    float sun_glint_lat:_FillValue=9.9692099683868690e+36f;
    string sun_glint_lat:coverage_content_type="referenceInformation";

float sun_glint_lon(atrack);
    string sun_glint_lon:units="degrees_east";
    float sun_glint_lon:valid_range=-180.0, 180.0;
    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.";
    float sun_glint_lon:_FillValue=9.9692099683868690e+36f;
    string sun_glint_lon:coverage_content_type="referenceInformation";

float sol_zen(atrack, xtrack, fov);
    string sol_zen:units="degree";
    float sol_zen:valid_range=0.0, 180.0;
    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 FOV";
    float sol_zen:_FillValue=9.9692099683868690e+36f;
    string sol_zen:coverage_content_type="referenceInformation";

float sol_azi(atrack, xtrack, fov);
    string sol_azi:units="degree";
    float sol_azi:valid_range=0.0, 360.0;
    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 FOV
(clockwise from North)";
    float sol_azi:_FillValue=9.9692099683868690e+36f;
    string sol_azi:coverage_content_type="referenceInformation";

float sun_glint_dist(atrack, xtrack, fov);
    string sun_glint_dist:units="m";
    float sun_glint_dist:valid_range=0.0, 30000000.0;
    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 FOV";
    float sun_glint_dist:_FillValue=9.9692099683868690e+36f;
    string sun_glint_dist:coverage_content_type="referenceInformation";

float view_ang(atrack, xtrack, fov);
    string view_ang:units="degree";
    float view_ang:valid_range=0.0, 180.0;
    string view_ang:long_name="view angle";

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string view_ang:standard_name="sensor_view_angle";
string view_ang:coordinates="lon lat";
string view_ang:description="off nadir pointing angle";
float view_ang:_FillValue=9.9692099683868690e+36f;
string view_ang:coverage_content_type="referenceInformation";

float sat_zen(atrack, xtrack, fov);
string sat_zen:units="degree";
float sat_zen:valid_range=0.0, 180.0;
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 FOV";
float sat_zen:_FillValue=9.9692099683868690e+36f;
string sat_zen:coverage_content_type="referenceInformation";

float sat_azi(atrack, xtrack, fov);
string sat_azi:units="degree";
float sat_azi:valid_range=0.0, 360.0;
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 FOV
(clockwise from North)";
float sat_azi:_FillValue=9.9692099683868690e+36f;
string sat_azi:coverage_content_type="referenceInformation";

float sat_range(atrack, xtrack, fov);
string sat_range:units="m";
float sat_range:valid_range=1.0e5, 1.0e7;
string sat_range:long_name="satellite range";
string sat_range:coordinates="lon lat";
string sat_range:description="line of sight distance between satellite and FOV
center";
float sat_range:_FillValue=9.9692099683868690e+36f;
string sat_range:coverage_content_type="referenceInformation";

ubyte asc_flag(atrack);
string asc_flag:units="1";
ubyte asc_flag:valid_range=0, 1;
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";
ubyte asc_flag:_FillValue=255ub;
string asc_flag:coverage_content_type="referenceInformation";
string asc_flag:flag_meanings="descending ascending";
ubyte asc_flag:flag_values=0, 1;

float subsat_lat(atrack); // standard_name platform_latitude is under review for a
future CF version
string subsat_lat:units="degrees_north";
float subsat_lat:valid_range=-90.0, 90.0;
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";
float subsat_lat:_FillValue=9.9692099683868690e+36f;
string subsat_lat:coverage_content_type="referenceInformation";

float subsat_lon(atrack); // standard_name platform_longitude is under review for
a future CF version
string subsat_lon:units="degrees_east";
float subsat_lon:valid_range=-180.0, 180.0;

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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";
float subsat_lon:_FillValue=9.9692099683868690e+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";
double scan_mid_time:valid_range=-2934835217.0, 3376598410.0;
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";
double scan_mid_time:_FillValue=9.9692099683868690e+36f;
string scan_mid_time:coverage_content_type="referenceInformation";

float sat_alt(atrack); // standard_name platform_altitude is under review for a
future CF version
string sat_alt:units="m";
float sat_alt:valid_range=1.0e5, 1.0e6;
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";
float sat_alt:_FillValue=9.9692099683868690e+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";
float sat_pos:_FillValue=9.9692099683868690e+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";
float sat_vel:_FillValue=9.9692099683868690e+36f;
string sat_vel:coverage_content_type="referenceInformation";

float sat_att(atrack, attitude);
string sat_att:units="degree";
float sat_att:valid_range=-180.0, 180.0;
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.";
float sat_att:_FillValue=9.9692099683868690e+36f;
string sat_att:coverage_content_type="referenceInformation";

float local_solar_time(atrack, xtrack, fov);
string local_solar_time:units="hours";
float local_solar_time:valid_range=0.0, 24.0;
string local_solar_time:long_name="local apparent solar time";

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string local_solar_time:coordinates="lon lat";
string local_solar_time:description="local apparent solar time in hours from
midnight";
    float local_solar_time:_FillValue=9.9692099683868690e+36f;
string local_solar_time:coverage_content_type="referenceInformation";

float mean_anom_wrt_equat(atrack);
string mean_anom_wrt_equat:units="degrees";
    float mean_anom_wrt_equat:valid_range=0.0, 360.0;
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";
    float mean_anom_wrt_equat:_FillValue=9.9692099683868690e+36f;
string mean_anom_wrt_equat:coverage_content_type="referenceInformation";

float sat_sol_zen(atrack);
string sat_sol_zen:units="degrees";
    float sat_sol_zen:valid_range=0.0, 180.0;
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";
    float sat_sol_zen:_FillValue=9.9692099683868690e+36f;
string sat_sol_zen:coverage_content_type="referenceInformation";

float sat_sol_azi(atrack);
string sat_sol_azi:units="degrees";
    float sat_sol_azi:valid_range=0.0, 360.0;
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)";
    float sat_sol_azi:_FillValue=9.9692099683868690e+36f;
string sat_sol_azi:coverage_content_type="referenceInformation";

float asc_node_lon;
string asc_node_lon:units="degrees_east";
    float asc_node_lon:valid_range=-180.0, 180.0;
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.";
    float asc_node_lon:_FillValue=9.9692099683868690e+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";
double asc_node_tai93:valid_range=-2934835217.0, 3376598410.0;
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.";
double asc_node_tai93:_FillValue=9.9692099683868690e+36f;
string asc_node_tai93:coverage_content_type="referenceInformation";

float asc_node_local_solar_time;
string asc_node_local_solar_time:units="hours";
    float asc_node_local_solar_time:valid_range=0.0, 24.0;
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";
    float asc_node_local_solar_time:_FillValue=9.9692099683868690e+36f;
string asc_node_local_solar_time:coverage_content_type="referenceInformation";
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float solar_beta_angle;
    string solar_beta_angle:units="degrees";
    float solar_beta_angle:valid_range=-90.0, 90.0;
    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.";
    float solar_beta_angle:_FillValue=9.9692099683868690e+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 rad_lw(atrack, xtrack, fov, wnum_lw);
    string rad_lw:units="mW/(m2 sr cm-1)";
    string rad_lw:ancillary_variables="rad_lw_qc";
    string rad_lw:long_name="longwave real spectral radiance";
    string rad_lw:standard_name="toa_outgoing_radiance_per_unit_wavenumber";
    string rad_lw:coordinates="lon lat";
    string rad_lw:description="longwave real spectral radiance";
    float rad_lw:_FillValue=9.9692099683868690e+36f;
    string rad_lw:coverage_content_type="physicalMeasurement";

byte rad_lw_qc(atrack, xtrack, fov);
    string rad_lw_qc:units="1";
    byte rad_lw_qc:valid_range=0, 2;
    string rad_lw_qc:long_name="rad_lw QC";
    string rad_lw_qc:standard_name="toa_outgoing_radiance_per_unit_wavenumber
status_flag";
    string rad_lw_qc:coordinates="lon lat";
    string rad_lw_qc:description="rad_lw QC flag";
    byte rad_lw_qc:_FillValue=-1b;
    string rad_lw_qc:coverage_content_type="qualityInformation";
    string rad_lw_qc:flag_meanings="Best Good Do_Not_Use";
    byte rad_lw_qc:flag_values=0, 1, 2;

float rad_mw(atrack, xtrack, fov, wnum_mw);
    string rad_mw:units="mW/(m2 sr cm-1)";
    string rad_mw:ancillary_variables="rad_mw_qc";
    string rad_mw:long_name="midwave real spectral radiance";
    string rad_mw:standard_name="toa_outgoing_radiance_per_unit_wavenumber";
    string rad_mw:coordinates="lon lat";
    string rad_mw:description="midwave real spectral radiance";
    float rad_mw:_FillValue=9.9692099683868690e+36f;
    string rad_mw:coverage_content_type="physicalMeasurement";

```

```

byte rad_mw_qc(atrack, xtrack, fov);
  string rad_mw_qc:units="1";
  byte rad_mw_qc:valid_range=0, 2;
  string rad_mw_qc:long_name="rad_mw QC";
  string rad_mw_qc:standard_name="toa_outgoing_radiance_per_unit_wavenumber
status_flag";
  string rad_mw_qc:coordinates="lon lat";
  string rad_mw_qc:description="rad_mw QC flag";
  byte rad_mw_qc:FillValue=-1b;
  string rad_mw_qc:coverage_content_type="qualityInformation";
  string rad_mw_qc:flag_meanings="Best Good Do_Not_Use";
  byte rad_mw_qc:flag_values=0, 1, 2;

float rad_sw(atrack, xtrack, fov, wnum_sw);
  string rad_sw:units="mW/(m2 sr cm-1)";
  string rad_sw:ancillary_variables="rad_sw_qc";
  string rad_sw:long_name="shortwave real spectral radiance";
  string rad_sw:standard_name="toa_outgoing_radiance_per_unit_wavenumber";
  string rad_sw:coordinates="lon lat";
  string rad_sw:description="shortwave real spectral radiance";
  float rad_sw:FillValue=9.9692099683868690e+36f;
  string rad_sw:coverage_content_type="physicalMeasurement";

byte rad_sw_qc(atrack, xtrack, fov);
  string rad_sw_qc:units="1";
  byte rad_sw_qc:valid_range=0, 2;
  string rad_sw_qc:long_name="rad_sw QC";
  string rad_sw_qc:standard_name="toa_outgoing_radiance_per_unit_wavenumber
status_flag";
  string rad_sw_qc:coordinates="lon lat";
  string rad_sw_qc:description="rad_sw QC flag";
  byte rad_sw_qc:FillValue=-1b;
  string rad_sw_qc:coverage_content_type="qualityInformation";
  string rad_sw_qc:flag_meanings="Best Good Do_Not_Use";
  byte rad_sw_qc:flag_values=0, 1, 2;

int cal_qualflag(atrack, xtrack, fov);
  string cal_qualflag:units="1";
  string cal_qualflag:long_name="L1B quality flags";
  string cal_qualflag:coordinates="lon lat";
  string cal_qualflag:description="per-observation L1B product quality";
  int cal_qualflag:FillValue=-2147483647;
  string cal_qualflag:coverage_content_type="qualityInformation";
  string cal_qualflag:flag_meanings="geo_quality_invalid inv_instrument_temp
excess_temp_drift fce_detected fce_correction_fail neon_cal_quality_flag isa_degraded_flag
lla_bit_trim_mismatch lla_eight_sec_missing";
  int cal_qualflag:flag_masks=1, 2, 4, 8, 16, 32, 64,
  128, 256;
  int cal_qualflag:flag_values=1, 2, 4, 8, 16, 32, 64,
  128, 256;

int cal_lw_qualflag(atrack, xtrack, fov);
  string cal_lw_qualflag:units="1";
  string cal_lw_qualflag:long_name="LW quality flags";
  string cal_lw_qualflag:coordinates="lon lat";
  string cal_lw_qualflag:description="per-observation L1B LW product quality";
  int cal_lw_qualflag:FillValue=-2147483647;
  string cal_lw_qualflag:coverage_content_type="qualityInformation";
  string cal_lw_qualflag:flag_meanings="quality_degraded quality_invalid
rad_cal_qual_degraded rad_cal_qual_invalid spectral_cal_qual_degraded
spectral_cal_qual_invalid imag_rad_anomaly lunar_intrusion lla_missing_es";
  int cal_lw_qualflag:flag_masks=3, 3, 12, 12, 48, 48, 64, 64,
  128, 256;
  int cal_lw_qualflag:flag_values=1, 2, 4, 8, 16, 32, 64, 128, 256;

```

```

int cal_mw_qualflag(atrack, xtrack, fov);
  string cal_mw_qualflag:units="1";
  string cal_mw_qualflag:long_name="MW quality flags";
  string cal_mw_qualflag:coordinates="lon lat";
  string cal_mw_qualflag:description="per-observation L1B MW product quality";
  int cal_mw_qualflag:_FillValue=-2147483647;
  string cal_mw_qualflag:coverage_content_type="qualityInformation";
  string cal_mw_qualflag:flag_meanings="quality degraded quality_invalid
rad_cal_qual_degraded rad_cal_qual_invalid spectral_cal_qual_degraded
spectral_cal_qual_invalid imag_rad_anomaly lunar_intrusion lla_missing_es";
  int cal_mw_qualflag:flag_masks=3, 3, 12, 12, 48, 48, 64,
                                128, 256;
  int cal_mw_qualflag:flag_values=1, 2, 4, 8, 16, 32,
                                64, 128, 256;

int cal_sw_qualflag(atrack, xtrack, fov);
  string cal_sw_qualflag:units="1";
  string cal_sw_qualflag:long_name="SW quality flags";
  string cal_sw_qualflag:coordinates="lon lat";
  string cal_sw_qualflag:description="per-observation L1B SW product quality";
  int cal_sw_qualflag:_FillValue=-2147483647;
  string cal_sw_qualflag:coverage_content_type="qualityInformation";
  string cal_sw_qualflag:flag_meanings="quality degraded quality_invalid
rad_cal_qual_degraded rad_cal_qual_invalid spectral_cal_qual_degraded
spectral_cal_qual_invalid imag_rad_anomaly lunar_intrusion lla_missing_es";
  int cal_sw_qualflag:flag_masks=3, 3, 12, 12, 48, 48, 64,
                                128, 256;
  int cal_sw_qualflag:flag_values=1, 2, 4, 8, 16, 32,
                                64, 128, 256;

float nedn_lw(fov, wnum_lw);
  string nedn_lw:units="mW/(m2 sr cm-1)";
  string nedn_lw:long_name="longwave noise equivalent differential radiance";
  string nedn_lw:description="longwave noise equivalent differential radiance";
  float nedn_lw:_FillValue=9.9692099683868690e+36f;
  string nedn_lw:coverage_content_type="qualityInformation";

float nedn_mw(fov, wnum_mw);
  string nedn_mw:units="mW/(m2 sr cm-1)";
  string nedn_mw:long_name="midwave noise equivalent differential radiance";
  string nedn_mw:description="midwave noise equivalent differential radiance";
  float nedn_mw:_FillValue=9.9692099683868690e+36f;
  string nedn_mw:coverage_content_type="qualityInformation";

float nedn_sw(fov, wnum_sw);
  string nedn_sw:units="mW/(m2 sr cm-1)";
  string nedn_sw:long_name="shortwave noise equivalent differential radiance";
  string nedn_sw:description="shortwave noise equivalent differential radiance";
  float nedn_sw:_FillValue=9.9692099683868690e+36f;
  string nedn_sw:coverage_content_type="qualityInformation";

ubyte scan_sweep_dir(xtrack);
  string scan_sweep_dir:units="1";
  ubyte scan_sweep_dir:valid_range=0, 1;
  string scan_sweep_dir:long_name="sweep direction of FOVs within a scan";
  string scan_sweep_dir:description="sweep direction of FOVs within a scan";
  ubyte scan_sweep_dir:_FillValue=255ub;
  string scan_sweep_dir:coverage_content_type="auxiliaryInformation";
  string scan_sweep_dir:flag_meanings="forward reverse";
  ubyte scan_sweep_dir:flag_values=0, 1;

ubyte for_num(xtrack);
  string for_num:units="1";

```

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```
    ubyte for_num:valid_range=1, 30;
    string for_num:long_name="field of regard number";
    string for_num:description="field of regard number";
    ubyte for_num:_FillValue=255ub;
    string for_num:coverage_content_type="auxiliaryInformation";

    ubyte fov_num(fov);
    string fov_num:units="1";
    ubyte fov_num:valid_range=1, 9;
    string fov_num:long_name="field of view number";
    string fov_num:description="field of view number";
    ubyte fov_num:_FillValue=255ub;
    string fov_num:coverage_content_type="auxiliaryInformation";

    double wnum_lw(wnum_lw);
    string wnum_lw:units="cm-1";
    double wnum_lw:valid_range=648.75, 1096.25;
    string wnum_lw:long_name="longwave wavenumber";
    string wnum_lw:standard_name="sensor_band_central_radiation_wavenumber";
    string wnum_lw:description="longwave wavenumber";
    double wnum_lw:_FillValue=9.9692099683868690e+36;
    string wnum_lw:coverage_content_type="auxiliaryInformation";

    double wnum_mw(wnum_mw);
    string wnum_mw:units="cm-1";
    double wnum_mw:valid_range=1207.5, 1752.5;
    string wnum_mw:long_name="midwave wavenumber";
    string wnum_mw:standard_name="sensor_band_central_radiation_wavenumber";
    string wnum_mw:description="midwave wavenumber";
    double wnum_mw:_FillValue=9.9692099683868690e+36;
    string wnum_mw:coverage_content_type="auxiliaryInformation";

    double wnum_sw(wnum_sw);
    string wnum_sw:units="cm-1";
    double wnum_sw:valid_range=2150.0, 2555.0;
    string wnum_sw:long_name="shortwave wavenumber";
    string wnum_sw:standard_name="sensor_band_central_radiation_wavenumber";
    string wnum_sw:description="shortwave wavenumber";
    double wnum_sw:_FillValue=9.9692099683868690e+36;
    string wnum_sw:coverage_content_type="auxiliaryInformation";

data:
    attitude_lbl="Roll", "Pitch", "Yaw";
    spatial_lbl="X", "Y", "Z";
    utc_tuple_lbl="year", "month", "day", "hour", "minute",
                 "second", "millisecond", "microsecond";
    scan_sweep_dir=0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0,
0.0,
                 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0, 0.0, 1.0,
0.0, 1.0;
    for_num=1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0, 11.0, 12.0, 13.0,
                14.0, 15.0, 16.0, 17.0, 18.0, 19.0, 20.0, 21.0, 22.0, 23.0, 24.0, 25.0,
26.0,
                27.0, 28.0, 29.0, 30.0;
    fov_num=1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0;

group: aux {
variables:
    int geo_qualflag(atrack, xtrack, fov);
    string geo_qualflag:units="1";
    string geo_qualflag:long_name="geolocation quality flags";
    string geo_qualflag:coordinates="lon lat";
    string geo_qualflag:description="per-observation L1B geolocation quality";
```

```

        int geo_qualflag:_FillValue=-2147483647;
        string geo_qualflag:coverage_content_type="qualityInformation";
        string geo_qualflag:flag_meanings="obs_time_missing servo_error_missing
scd_gap_sm scd_gap_md scd_gap_lg stale_utcpole";
        int geo_qualflag:flag_masks=1, 2, 12, 12, 12, 16;
        int geo_qualflag:flag_values=1, 2, 4, 8, 12, 16;

float rad_imag_lw(atrack, xtrack, fov, wnum_lw);
string rad_imag_lw:units="mW/(m2 sr cm-1)";
string rad_imag_lw:long_name="longwave imaginary spectral radiance";
string
rad_imag_lw:standard_name="toa_outgoing_radiance_per_unit_wavenumber";
string rad_imag_lw:coordinates="lon lat";
string rad_imag_lw:description="longwave imaginary spectral radiance";
float rad_imag_lw:_FillValue=9.9692099683868690e+36f;
string rad_imag_lw:coverage_content_type="qualityInformation";

float rad_imag_mw(atrack, xtrack, fov, wnum_mw);
string rad_imag_mw:units="mW/(m2 sr cm-1)";
string rad_imag_mw:long_name="midwave imaginary spectral radiance";
string
rad_imag_mw:standard_name="toa_outgoing_radiance_per_unit_wavenumber";
string rad_imag_mw:coordinates="lon lat";
string rad_imag_mw:description="midwave imaginary spectral radiance";
float rad_imag_mw:_FillValue=9.9692099683868690e+36f;
string rad_imag_mw:coverage_content_type="qualityInformation";

float rad_imag_sw(atrack, xtrack, fov, wnum_sw);
string rad_imag_sw:units="mW/(m2 sr cm-1)";
string rad_imag_sw:long_name="shortwave imaginary spectral radiance";
string
rad_imag_sw:standard_name="toa_outgoing_radiance_per_unit_wavenumber";
string rad_imag_sw:coordinates="lon lat";
string rad_imag_sw:description="shortwave imaginary spectral radiance";
float rad_imag_sw:_FillValue=9.9692099683868690e+36f;
string rad_imag_sw:coverage_content_type="qualityInformation";

double max_opd_lw;
string max_opd_lw:units="cm";
string max_opd_lw:long_name="maximum longwave optical path difference";
string max_opd_lw:description="maximum longwave optical path difference";
double max_opd_lw:_FillValue=9.9692099683868690e+36;
string max_opd_lw:coverage_content_type="qualityInformation";

double max_opd_mw;
string max_opd_mw:units="cm";
string max_opd_mw:long_name="maximum midwave optical path difference";
string max_opd_mw:description="maximum midwave optical path difference";
double max_opd_mw:_FillValue=9.9692099683868690e+36;
string max_opd_mw:coverage_content_type="qualityInformation";

double max_opd_sw;
string max_opd_sw:units="cm";
string max_opd_sw:long_name="maximum shortwave optical path difference";
string max_opd_sw:description="maximum shortwave optical path difference";
double max_opd_sw:_FillValue=9.9692099683868690e+36;
string max_opd_sw:coverage_content_type="qualityInformation";

short spectral_fold_point_lw;
string spectral_fold_point_lw:units="1";
string spectral_fold_point_lw:long_name="longwave spectral folding index";

```


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```
        string spectral_fold_point_lw:description="one-based index for unfolding
uncalibrated longwave spectrum into ascending wavenumbers";
        short spectral_fold_point_lw:_FillValue=-32767s;
        string
spectral_fold_point_lw:coverage_content_type="auxiliaryInformation";

        short spectral_fold_point_mw;
        string spectral_fold_point_mw:units="1";
        string spectral_fold_point_mw:long_name="midwave spectral folding index";
        string spectral_fold_point_mw:description="one-based index for unfolding
uncalibrated midwave spectrum into ascending wavenumbers";
        short spectral_fold_point_mw:_FillValue=-32767s;
        string
spectral_fold_point_mw:coverage_content_type="auxiliaryInformation";

        short spectral_fold_point_sw;
        string spectral_fold_point_sw:units="1";
        string spectral_fold_point_sw:long_name="shortwave spectral folding
index";
        string spectral_fold_point_sw:description="one-based index for unfolding
uncalibrated shortwave spectrum into ascending wavenumbers";
        short spectral_fold_point_sw:_FillValue=-32767s;
        string
spectral_fold_point_sw:coverage_content_type="auxiliaryInformation";

        double measured_laser_wlen;
        string measured_laser_wlen:units="nm";
        double measured_laser_wlen:valid_range=695.0, 850.0;
        string measured_laser_wlen:long_name="measured metrology laser half-
wavelengths";
        string measured_laser_wlen:description="measured metrology laser half-
wavelengths";
        double measured_laser_wlen:_FillValue=9.9692099683868690e+36;
        string measured_laser_wlen:coverage_content_type="qualityInformation";

        double smoothed_laser_wlen;
        string smoothed_laser_wlen:units="nm";
        string smoothed_laser_wlen:long_name="smoothed metrology laser half-
wavelengths";
        string smoothed_laser_wlen:description="smoothed metrology laser half-
wavelengths";
        double smoothed_laser_wlen:_FillValue=9.9692099683868690e+36;
        string smoothed_laser_wlen:coverage_content_type="qualityInformation";

        double smoothed_neon_wlen;
        string smoothed_neon_wlen:units="nm";
        string smoothed_neon_wlen:long_name="smoothed neon laser half-
wavelengths";
        string smoothed_neon_wlen:description="smoothed neon laser half-
wavelengths";
        double smoothed_neon_wlen:_FillValue=9.9692099683868690e+36;
        string smoothed_neon_wlen:coverage_content_type="qualityInformation";

        double neon_wlen;
        string neon_wlen:units="nm";
        string neon_wlen:long_name="neon laser half-wavelengths";
        string neon_wlen:description="neon laser half-wavelengths";
        double neon_wlen:_FillValue=9.9692099683868690e+36;
        string neon_wlen:coverage_content_type="qualityInformation";

    } // aux
} // snpp_llb_cris_fsr
```

