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

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1. Introduction

1.1 Overview

This document describes Version 3 of the NASA Cross-track Infrared Sounder (CrIS) Level 1B (L1B) data products.

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

The goal of creating these products is to provide a high-quality, consistently calibrated dataset spanning the Suomi NPP (SNPP) and NOAA-20 / JPSS-1 (J1) missions, for use in climatology and other applications where long-term stability is a primary consideration.

Major improvements in the Version 3 products include polarization correction, correction of Doppler shift due to the rotation of the Earth, fringe count error detection and correction, reduced spectral ringing, improved detection and exclusion of outliers in calibration views, detection and flagging of anomalous spikes in Earth scene interferograms, and support for calculation of radiometric uncertainty via added output variables. For a complete list of improvements in this product version, refer to Section 1.5.

A single version of the CrIS L1B software was used to generate the Version 3 products. By comparison, different versions of the software were used to generate the Version 2 SNPP and J1 products, potentially introducing minor differences across instruments.

While SNPP products are provided at both Normal Spectral Resolution (NSR) and Full Spectral Resolution (FSR), the J1 product is provided only at FSR. For more information, refer to Sections 2.2 and 3.3.

Table 1.1- 1 NASA CrIS Level 1B Version 3 products.

Product	DOI
Suomi NPP Normal Spectral Resolution	10.5067/OZZPDWENP2NC
Suomi NPP Full Spectral Resolution	10.5067/ZCRSHBM5HB23
NOAA-20 / JPSS-1 Full Spectral Resolution	10.5067/LVEKYTNSRNKP

The file format of the CrIS L1B products is NetCDF-4. 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).

These products were generated by Version 3.0.1 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 3 CrIS L1B data products are released to the public as is.

1.3 Obtaining the Products

The CrIS Level 1B products can be downloaded from NASA's Goddard Earth Sciences Data and Information Services Center (GES DISC), or refer to the DOIs shown in Table 1.1.

https://disc.gsfc.nasa.gov

1.4 Contact Information

Inquiries regarding the data products 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 3 and the earlier Version 2 products are:

Level 1B calibration:

- Implemented polarization correction.
- Improvements to detection of lunar intrusion in space views. Space views that are identified as outliers (due to lunar intrusion or other) are not included in the deep space calibration reference moving average, and improved detection improves the calibration robustness and quality.
- Added detection of Internal Calibration Target (ICT) outliers. ICT views that are identified as outliers are not included in the ICT calibration reference moving average, and improved detection improves the calibration robustness and quality.
- Implemented correction for Doppler shift due to the rotation of the Earth.
- Implemented fringe count error (FCE) detection and correction. While only one real FCE event has occurred for SNPP, the implementation of fringe count error detection and correction makes the calibration robust to FCE events.
- Calculation of Radiometric Uncertainty (RU) is now supported via variables that were added to the aux group.
- Reduction in ringing due to addition of weak cosine interferogram rolloff.
- Added safeguards against using fill data in L1B processing, and any NaNs in L1B files resulting from bad data should now be replaced by fill values.
- Removed spectral smoothing of noise estimate.

- Updates to maintain consistent performance of the SNPP shortwave and longwave datasets during the period between the CrIS midwave signal processor failure on March 26, 2019, and the electronics side change on June 24, 2019.
- NOAA-20/JPSS-1, SNPP Side 1 and SNPP Side 2 datasets are all generated with the same software version.
- Minor improvements to the spectral calibration in the J1 SW band. The FOV geometry from the v115 engineering packet was used to calculate the inverse self apodization matrices, which were then applied across the entire J1 mission.

Quality monitoring:

- Implemented detection of anomalous spikes in Earth scene interferograms.
- Improvements to imaginary thresholds to more accurately flag bad spectra.
- Quality flags and QC values are now properly set in granules with all missing data.
- Improvements to logic for setting file-level summary attributes (qa_*) to more accurately calculate statistics.
- Added L1B quality flag bits for Internal Calibration Target outlier and Earth Scene spike.
- Added fringe count error detected and fringe count error corrected flag bits.
- The meaning of the values of the file-level attribute AutomaticQualityFlag have been changed to make them more useful, and the logic to set them has been changed accordingly.
- Added summary attributes to radiance variables indicating percent of observations in each quality control category (qc_pct*).
- Added auxiliary variables to be used for diagnostic purposes, monitoring, and RU calculation; eliminated superfluous variables that were previously included but not populated.

Geolocation:

- Fixed issues with the geospatial_bounds attribute: latitude and longitude values have been corrected to be listed in (lon, lat) order as to comply with the EPSG:4326 coordinate system, and a problem that could result in NaN values was also fixed.
- The sun glint calculation in the geolocation module has been refined to model the earth using the WGS84 ellipsoid.
- (SNPP-only) Added a geolocation correction for the slight alignment difference between the spacecraft and sensor coordinate systems. A number of other small (order of a few meters) geolocation fixes are also included. These corrections were previously made for NOAA-20/JPSS-1 in the V2 product.

Metadata:

- Values in the time_of_first_valid_obs and time_of_last_valid_obs attributes are now based on actual earth observation times in that granule, consistent with L1A attributes.
- The precision of the time_coverage_{start,mid,end} attributes is now set to two decimals, consistent with Sounder SIPS guidance.
- History attribute now contains the user command-line invocation rather than the core software invocation.
- Added summary attributes to main L1B product variables indicating percent of observations that fall into each quality category (qc_pct_best, qc_pct_good, qc_pct_do_not_use).
- Added attributes to L1B files indicating input and output data resolution (interferogram_resolution, spectral_resolution) and spectral grid spacing (wnum_delta_*).
- Fixed minor attribute issues to improve CF compliance in L1B files.

- Added "AIRS_HDF_name" attribute to some variables mapping to the equivalent AIRS variable names.

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). A second CrIS instrument is on the J1 satellite, launched on November 18, 2017 into an orbit with the same altitude and orbital plane as SNPP but 180 degrees out of phase (so the pair of satellites is on opposite sides of the earth at all times).

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 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 SNPP 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.

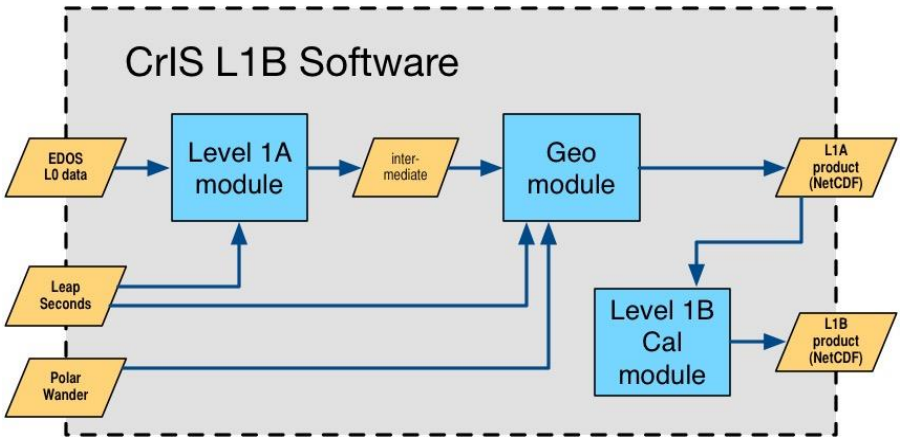
On November 2, 2015, SNPP began transmitting long-wave and short-wave interferograms with extra points on the ends. Level 0 data received from this time onward is referred to as Extended Spectral Resolution (XSR). These points had previously been discarded, but were added to the data stream because it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

The resolution of CrIS Level 0 data received from J1 has been at XSR from day 1.

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 data. Additionally, modifications to the calibration algorithm and quality flag indicators have been incorporated.

For information on the theoretical basis of the CrIS L1B software, refer to the "NASA Cross Track Infrared Sounder (CrIS) Level 1B Delta Algorithm Theoretical Basis Document (ATBD), Version 3".

2.4 Product Generation

Software integration was done by the Sounder Science Investigator-led Processing System (SIPS), located at JPL and Goddard Earth Sciences Data Information Services Center (GES DISC). The products were generated from EOS Data and Operations System (EDOS) Level 0 data at GES DISC.

3. CrIS L1B Products

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 data are written to separate files, with the same granulation.

The L1A data consists of raw telemetry values that have been decoded and unscaled, as well as bit-trimmed interferograms, geolocation data, quality flags and other metadata. A L1A data product has not been released and the format has not been documented. However, formalization of the L1A data format and release of L1A products and accompanying documentation is planned in the future.

The L1B data 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 data is described in this document.

3.3 NSR vs FSR Products

As described in Section 2.2, the resolution of CrIS data as received from the SNPP satellite was increased several years into the mission. It was decided to produce SNPP L1B products at two different resolutions, to meet the goals of providing spectrally consistent products with the longest

possible duration and also with the highest possible spectral resolution. These L1B products are referred to as NSR and FSR.

The SNPP NSR product has a lower resolution in the short-wave and mid-wave spectra compared to the long-wave. 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 SNPP FSR product 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 J1 FSR product has the same spectral resolution as the SNPP FSR product, and spans the entire J1 mission.

Table 3.3- 1 Comparison of NSR and FSR L1B Products.

	SNPP NSR L1B product	SNPP FSR L1B product	J1 FSR L1B product
Start date	April 19, 2012 (granule 001)	November 2, 2015 (granule 162)	February 17, 2018 (granule 001)
Long-wave resolution (cm^{-1})	0.625	0.625	0.625
Mid-wave resolution (cm^{-1})	1.25	0.625	0.625
Short-wave resolution (cm^{-1})	2.5	0.625	0.625

The NSR and FSR prodcuts are distributed as separate sets of 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, and mid-wave data restored, by switching from the Side 1 electronics to the redundant Side 2 electronics on June 24, 2019.

After the side change, calibration parameters for Side 2 operation were determined, and the updated parameters were used to generate the Side 2 portion of the SNPP mission products.

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

- Quality issues in mid-wave beginning on 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 products.
- 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, in terms of their spectral ringing characteristics, compared to the earlier datasets 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 products 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.
- Small changes in the radiometric calibration, on the order of 5 mK, on 26 March and 25 June due to a combination of sensor temperature changes (due to stoppage and restart of the mid-wave signal processor) and switch from Side 1 to Side 2 ICT PRTs.

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 NetCDF-4 files.

4.1 NetCDF-4

The product files can be read and queried using the NetCDF-4 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.

NetCDF-4 files are HDF5 files with additional bookkeeping information managed by the NetCDF-4 library. It is therefore possible to inspect and read data from the NetCDF-4 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".

Fortran users should note that many CrIS L1B attributes and some variables are stored using the string NetCDF-4 data type. The Fortran NetCDF-4 library from Unidata does not currently support the string data type. Potential workarounds include using the HDF5 library or a Fortran-callable function written in C if access to string-valued attributes or variables is required.

Matlab users should note that the Matlab NetCDF-4 interface is currently (as of version R2020a) not able to read variables that contain 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. MathWorks is aware of this issue and may address it in a future version of Matlab.

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_nam
e_variant>.<product_name_version>.<product_name_producer>.<product_name_times
tamp>.<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 v3 products	Description
product_name_project	nnnn	SNDR	Sounder SIPS ID
product_name_platform	pppp	J1 or SNPP	Satellite platform, where J1 indicates NOAA-20 / JPSS-1
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	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	v03_##	[unknown]	Product version
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.J1.CRIS.20180913T1112.m06.g113.L1B.std.v03_00.G.181117090149.nc
```

4.5 Time Representation

Times in the CrIS L1B products 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 NetCDF-4 format data files and requires a recent version of the Unidata NetCDF library to access content. NetCDF-4 is effectively a specialization of the HDF5 format, unlike NetCDF-3 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 NetCDF-4 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".

Abbreviations used in dimension and variable names are defined in "Appendix C".

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 product 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 product 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 at NASA GES DISC via configuration files, and some are set dynamically at runtime by the L1B software based on the data being processed.

The static attribute "algorithm_version" can be used to distinguish the product software semantic version ("vM.N.P", with M as major release, N as minor release, and P as patch release) across all CrIS L1B product files, and will read as "v3.0.1" for this revision.

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

Table 5.2- 1 CrIS L1B Dynamic Global Attributes.

Attribute Name	Type	Description	Heritage
AutomaticQualityFlag	string	'"Passed": all spectra are present and calibrated with no quality issues; "Suspect": at least one spectrum is missing or calibrated with quality issues; "Failed": no calibrated spectra.	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 values are longitude (decimal degrees_east) and latitude (decimal degrees_north), in that order. Longitude values in the default case are limited to the -180, 180) range. Example: "POLYGON ((-107.85 41.36, -133.88 44.99, -137.01 24.11, -116.47 21.32, -107.85 41.36))".	ACDD Recommended

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 LongranuleCen
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 input_file_names. There will always be one space after each semicolon. There is no final semicolon.	ISO Source Description
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 granule end time.	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 granule start time.	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"
qc_pct_best	float		Percent of observations that fall in the QC category "Best", for radiance variables
qc_pct_good	float		Percent of observations that fall in the QC category "Good", for radiance variables
qc_pct_do_not_use	float		Percent of observations that fall in the QC category "Do_Not_Use", for radiance variables

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/(m2 sr cm-1)	Long-wave real spectral radiance
rad_mw	float32	atrack, xtrack, fov, wnum_mw	mW/(m2 sr cm-1)	Mid-wave real spectral radiance
rad_sw	float32	atrack, xtrack, fov, wnum_sw	mW/(m2 sr cm-1)	Short-wave real spectral radiance
NEdN				
nedn_lw	float32	fov, wnum_lw	mW/(m2 sr cm-1)	Long-wave noise equivalent differential radiance
nedn_mw	float32	fov, wnum_mw	mW/(m2 sr cm-1)	Mid-wave noise equivalent differential radiance
nedn_sw	float32	fov, wnum_sw	mW/(m2 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".

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

Quality information is available to the user in two forms:

- Quality Control (QC) variables that assign an integer quality score to each calibrated radiance spectrum.
- Quality Flag (QF) variables that describe in greater detail any issues affecting each calibrated radiance spectrum and associated geolocation.

Users should check quality information before using L1B data in analysis or processing.

It should be noted that quality degradation may be falsely indicated in granules that contain large data gaps or sparse content, due to a lack of the adjacent data required for accurate quality assessment.

A more complete description of quality information, including the meaning and derivation of QF bit-fields, is provided in the document "Cross-track Infrared Sounder (CrIS) Level 1B Quality Flags Description Document, Version 3".

5.8.1 Quality Control

For each radiance product variable (rad_lw, rad_mw, rad_sw), an associated Quality Control (QC) variable is available (rad_lw_qc, rad_mw_qc, rad_sw_qc) that assigns an integer quality score to each calibrated spectrum. The QC score is derived from the more detailed QF information, and indicates any data or processing related issues which may have affected calibration and geolocation.

QC values range from 0 to 2, where

- 0 ("best") indicates no quality issues were detected.
- 1 ("good") indicates minor quality issues were detected: the spectrum may be slightly degraded but is likely of acceptable quality for most end-users, and the geolocation may be invalid.
- 2 ("do not use") indicates that the spectrum is invalid.

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.

New in Version 3, the radiance variables (rad_lw, rad_mw and rad_sw) contain summary attributes (qc_pct_best, qc_pct_good, qc_pct_do_not_use) indicating the percentage of spectra that fall into each QC category.

5.8.2 Quality Flags

Similar to the QC variables, for each radiance product variable (rad_lw, rad_mw, rad_sw), an associated Quality Flag (QF) variable is available (cal_lw_qualflag, cal_mw_qualflag, cal_sw_qualflag) that provides detailed information about issues encountered during calibration of each spectrum, as well as the results of various tests and attempted corrections. In addition to the band-specific calibration QF variables, there is a band-independent calibration QF variable (cal_qualflag).

QF variables are bit-fields, composed of flags which can be one or more bits in length. Users can access the individual flags for information on the specific issues that were encountered.

The bit encoding of the three band-specific QFs is identical.

Each QF variable has attributes that fully describe the meaning and interpretation of individual flags at the bit-level ("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, 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 the same indices can be applied to both to access the relevant information.

Because the magnitude of the imaginary residual is a good indication of any errors in the calibration, the primary calibration 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.

In the Version 3 products, new L1B quality flag bits were defined using formerly spare bits, indicating Internal Calibration Target outlier excluded, and Earth Scene spike detected. In addition, bits related to Fringe Count Error detection and correction which were reserved in previous product versions are now populated.

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 products.

Table 5.8.2- 1 CrIS L1B Quality Flag Variables.

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

5.9 Granule and Observation IDs

Included in the products 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 3 products.

1. Due to leap second correction delays known to have occurred in the SNPP CrIS instrument system, product files may not be produced surrounding leap second transitions.

2. 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.

3. 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 in finer detail for the next release.

4. 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 for a future release.

5. 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").

6. 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.

7. References

1. NASA Cross Track Infrared Sounder (CrIS) Level 1B Delta Algorithm Theoretical Basis Document (ATBD), Version 3

2. Cross-track Infrared Sounder (CrIS) Level 1B Quality Flags Description Document, Version 3

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)

8. Revisions

Document Version	Product Version	Software Version	Date	Comment
1.0 Beta3	1 (Beta)	1.0 Beta3	24 Apr 2016	Release describing Version 1.0 Beta3 products
1.0	1	1.0RC8	01 May 2017	Release describing Version 1.0 products
1.0 Rev A	1	1.0RC8	12 Jun 2017	First revision of release describing Version 1.0 products. Includes the following changes: - Fixed link to data download location in Section 1.7 - Rewrote Section 2.4 for clarity (NSR vs FSR) - Clarification on use of HDF5 libraries in Section 3.1 - Added caveat regarding incorrect NEdN units in Section 5
2.0	2 (SNPP)	2.0.15	27 Apr 2018	Release describing Version 2 SNPP products - Reorganized Intro and Product sections, added a Background section. - Removed Appendix D, Quality Flag Information, as this can be found in the CrIS L1B Quality Flag Description Document. - Various other changes and clarifications for v2.
2.0 Rev A	2 (SNPP)	2.0.15	21 Jun 2018	First revision of release describing Version 2 SNPP products. Includes the following changes: - Added caveat regarding an ICT radiance model error.
2.11	2 (JPSS-1)	2.1.3	21 Dec 2018	Release describing v2 JPSS-1 products
2.0 Rev B	2 (SNPP)	2.0.16	7 Oct 2019	Second revision of release describing Version 2 SNPP products. Includes the following changes: - Describes impact of SNPP mid-wave signal processor failure on Version 2 product - Fixed typo in FSR MW dimension size
3	3	3.0.1	6 Oct 2020	Release describing v3 products (SNPP and JPSS-1)
3 Rev A	3	3.0.1	4 Nov 2020	- Added description of J1 SW band spectral cal improvements to "What's New" - Various minor improvements from reviewer feedback

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
```

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 NetCDF-4 library ("ncdump -h"). A CDL file shows the structure of the product file, including global attributes, groups, variables and variable attributes.

```
netcdf j1_l1b_cris_fsr  {
dimensions:
        utc_tuple = 8;  // parts of UTC time: year, month, day, hour, minute, second, millisec,
microsec
        atrack = 45;  // along-track horizontal dimension
        xtrack = 30;  // cross-track horizontal 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
        fov_poly = 8;  // lat_bnds, lon_bnds points defining the polygon bounding an FOV
(anticlockwise as viewed from above)
        spatial = 3;  // directions: x, y, z for satellite position and velocity
        attitude = 3;  // roll, pitch, yaw

// 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";  // A comma-separated list of the conventions
that are followed by the dataset.
        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.
Another problem: newer text on the ACDD webpage shows that longitude should come before latitude.
The text always said that but the old example showed latitude first.  With v03 we change to
longitude first.; 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 ((-111.29 40.26, -111.29 41.26, -110.29 41.26, -110.29 40.26, -111.29
40.26))'.
        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.
        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.; Describes the time of the last valid data point in the data
set. Use the ISO 8601:2004 date extended format.
        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="JPSS-1 > Joint Polar Satellite System - 1";  // 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="J1";  // 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 :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 :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 :identifier_product_doi="Unassigned";  // partly redundant with id but retained
for EOSDIS compatibility; digital signature
        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 publisted 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.  After the main algorithm name
and version, versions from multiple sub-algorithms may be concatenated with semicolon separators.
(ex: 'CCAST 4.2; BB emis from MIT 2016-04-01')  Must be updated with every delivery that changes
numerical results.
        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="v02.01.14";  // 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_AlgParam, 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":
all spectra are present and calibrated with no quality issues; "Suspect": at least one spectrum
is missing or calibrated with quality issues; "Failed": no calibrated spectra.
        string :AutomaticQualityFlagExplanation="'Passed': all spectra are present and calibrated
with no quality issues; 'Suspect': at least one spectrum is missing or calibrated with quality
issues; 'Failed': no calibrated spectra.";  // Can leave the default or override to give specific
```

```
per-gran info.; A text explanation of the criteria used to set AutomaticQualityFlag; including
thresholds or other criteria.
        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="TRUE";  // 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 :interferogram_resolution="Unassigned";  // Resolution of the inteferograms.
Allowed values are "NSR", "FSR", "XSR" and "Unassigned".
        string :spectral_resolution="Unassigned";  // Resolution of the spectra. Allowed values
are "NSR", "FSR", and "Unassigned".
        float :wnum_delta_lw=9.9692099683868690e+36f;  // Difference between adjacent wavenumbers
in longwave spectrum, in cm-1
        float :wnum_delta_mw=9.9692099683868690e+36f;  // Difference between adjacent wavenumbers
in midwave spectrum, in cm-1
        float :wnum_delta_sw=9.9692099683868690e+36f;  // Difference between adjacent wavenumbers
in shortwave spectrum, in cm-1
        string :title="JPSS-1 CrIS Level-1B FSR";  // a succinct description of what is in the
dataset. (= ECS long name)
        string :summary="The FSR CrIS Level 1B product consists of calibrated radiance spectra at
Full Spectral Resolution, as well as geolocation information, metadata and derived parameters
related to the observations.";  // A paragraph describing the dataset, analogous to an abstract
for a paper.
        string :shortname="SNDRJ1CrISL1B";  // ECS Short Name
        string :product_group="l1b_cris";  // The group name to be used for this product when it
is collected in a multi-group file type, like SNO or calsub
        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 Cross-track Infrared Sounder (CrIS) Level 1B Algorithm
Theoretical Basis Document (ATBD) Version 3.0; NASA Cross-track Infrared Sounder (CrIS) Level 1B
Product Users' Guide Version 3.0; NASA Cross-track Infrared Sounder (CrIS) Level 1B Quality Flags
Description Document Version 3.0";  // ATDB and design documents describing processing
algorithms. Can be empty.
        string :contributor_name="UW-Madison Space Science and Engineering Center: Joe K Taylor;
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:long_name="observation id for FOR";
                string obs_id:coverage_content_type="referenceInformation";
                string obs_id:description="unique observation identifier: yyyymmddThhmm.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 fov_obs_id(atrack, xtrack, fov);
                string fov_obs_id:long_name="observation id for FOV";
                string fov_obs_id:coverage_content_type="referenceInformation";
                string fov_obs_id:description="unique observation identifier for FOV:
yyyymmddThhmm.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).";

        ubyte instrument_state(atrack, xtrack, fov);
                string instrument_state:long_name="instrument state";
                string instrument_state:coordinates="lon lat";
                ubyte instrument_state:_FillValue=255ub;
                ubyte instrument_state:flag_values=0,  1,  2,  3;
                string instrument_state:coverage_content_type="qualityInformation";
                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.";
```

```
                string instrument_state:AIRS_HDF_name="state";
                string instrument_state:flag_meanings="Process Special Erroneous Missing";

        double obs_time_tai93(atrack, xtrack);
                double obs_time_tai93:valid_range=-2934835217.0,  3376598410.0;
                string obs_time_tai93:long_name="earth view FOV midtime";
                double obs_time_tai93:_FillValue=9.9692099683868690e+36;
                string obs_time_tai93:coverage_content_type="referenceInformation";
                string obs_time_tai93:standard_name="time";
                string obs_time_tai93:units="seconds since 1993-01-01 00:00";
                string obs_time_tai93:description="earth view observation midtime for each FOV";
                string obs_time_tai93:AIRS_HDF_name="Time";

        ushort obs_time_utc(atrack, xtrack, utc_tuple);
                string obs_time_utc:long_name="earth view UTC FOV time";
                string obs_time_utc:coordinates="utc_tuple_lbl";
                ushort obs_time_utc:_FillValue= 65535us;
                string obs_time_utc:coverage_content_type="referenceInformation";
                string obs_time_utc:description="UTC earth view observation time as an array of
integers: year, month, day, hour, minute, second, millisec, microsec";

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

        float lat_geoid(atrack, xtrack, fov);
                float lat_geoid:valid_range=-90.0,  90.0;
                string lat_geoid:long_name="latitude";
                float lat_geoid:_FillValue=9.9692099683868690e+36f;
                string lat_geoid:coverage_content_type="referenceInformation";
                string lat_geoid:standard_name="latitude";
                string lat_geoid:units="degrees_north";
                string lat_geoid:description="latitude of FOV center on the geoid (without terrain
correction)";

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

        float lon_geoid(atrack, xtrack, fov);
                float lon_geoid:valid_range=-180.0,  180.0;
                string lon_geoid:long_name="longitude";
                float lon_geoid:_FillValue=9.9692099683868690e+36f;
                string lon_geoid:coverage_content_type="referenceInformation";
                string lon_geoid:standard_name="longitude";
                string lon_geoid:units="degrees_east";
                string lon_geoid:description="longitude of FOV center on the geoid (without
terrain correction)";

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

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

        float land_frac(atrack, xtrack, fov);
                float land_frac:valid_range=0.0,  1.0;
                string land_frac:long_name="land fraction";
                string land_frac:coordinates="lon lat";
                float land_frac:_FillValue=9.9692099683868690e+36f;
                string land_frac:coverage_content_type="referenceInformation";
                string land_frac:standard_name="land_area_fraction";
                string land_frac:units="1";
                string land_frac:description="land fraction over the FOV";
                string land_frac:AIRS_HDF_name="landFrac";
                string land_frac:cell_methods="area: mean (beam-weighted)";

        float surf_alt(atrack, xtrack, fov);
                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:coordinates="lon lat";
                float surf_alt:_FillValue=9.9692099683868690e+36f;
                string surf_alt:coverage_content_type="referenceInformation";
                string surf_alt:standard_name="surface_altitude";
                string surf_alt:units="m";
                string surf_alt:description="mean surface altitude wrt  earth model over the FOV";
                string surf_alt:AIRS_HDF_name="topog";
                string surf_alt:cell_methods="area: mean (beam-weighted)";

        float surf_alt_sdev(atrack, xtrack, fov);
                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";
                float surf_alt_sdev:_FillValue=9.9692099683868690e+36f;
                string surf_alt_sdev:coverage_content_type="qualityInformation";
                string surf_alt_sdev:units="m";
                string surf_alt_sdev:description="standard deviation of surface altitude within
the FOV";
                string surf_alt_sdev:AIRS_HDF_name="topog_err";
                string surf_alt_sdev:cell_methods="area: standard_deviation (beam-weighted)";

        float sun_glint_lat(atrack);
                float sun_glint_lat:valid_range=-90.0,  90.0;
                string sun_glint_lat:long_name="sun glint latitude";
                string sun_glint_lat:coordinates="subsat_lon subsat_lat";
                float sun_glint_lat:_FillValue=9.9692099683868690e+36f;
                string sun_glint_lat:coverage_content_type="referenceInformation";
                string sun_glint_lat:standard_name="latitude";
                string sun_glint_lat:units="degrees_north";
                string sun_glint_lat:description="sun glint spot latitude at scan_mid_time.  Fill
for night observations.";
                string sun_glint_lat:AIRS_HDF_name="glintlat";

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

```
        float sol_zen(atrack, xtrack, fov);
                float sol_zen:valid_range=0.0,  180.0;
                string sol_zen:long_name="solar zenith angle";
                string sol_zen:coordinates="lon lat";
                float sol_zen:_FillValue=9.9692099683868690e+36f;
                string sol_zen:coverage_content_type="referenceInformation";
                string sol_zen:standard_name="solar_zenith_angle";
                string sol_zen:units="degree";
                string sol_zen:description="solar zenith angle at the center of the FOV";
                string sol_zen:AIRS_HDF_name="solzen";

        float sol_azi(atrack, xtrack, fov);
                float sol_azi:valid_range=0.0,  360.0;
                string sol_azi:long_name="solar azimuth angle";
                string sol_azi:coordinates="lon lat";
                float sol_azi:_FillValue=9.9692099683868690e+36f;
                string sol_azi:coverage_content_type="referenceInformation";
                string sol_azi:standard_name="solar_azimuth_angle";
                string sol_azi:units="degree";
                string sol_azi:description="solar azimuth angle at the center of the FOV
(clockwise from North)";
                string sol_azi:AIRS_HDF_name="solazi";

        float sun_glint_dist(atrack, xtrack, fov);
                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";
                float sun_glint_dist:_FillValue=9.9692099683868690e+36f;
                string sun_glint_dist:coverage_content_type="referenceInformation";
                string sun_glint_dist:units="m";
                string sun_glint_dist:description="distance of sun glint spot to the center of the
FOV";
                string sun_glint_dist:AIRS_HDF_name="sun_glint_distance";

        float view_ang(atrack, xtrack, fov);
                float view_ang:valid_range=0.0,  180.0;
                string view_ang:long_name="view angle";
                string view_ang:coordinates="lon lat";
                float view_ang:_FillValue=9.9692099683868690e+36f;
                string view_ang:coverage_content_type="referenceInformation";
                string view_ang:standard_name="sensor_view_angle";
                string view_ang:units="degree";
                string view_ang:description="off nadir pointing angle";
                string view_ang:AIRS_HDF_name="scanang";

        float sat_zen(atrack, xtrack, fov);
                float sat_zen:valid_range=0.0,  180.0;
                string sat_zen:long_name="satellite zenith angle";
                string sat_zen:coordinates="lon lat";
                float sat_zen:_FillValue=9.9692099683868690e+36f;
                string sat_zen:coverage_content_type="referenceInformation";
                string sat_zen:standard_name="sensor_zenith_angle";
                string sat_zen:units="degree";
                string sat_zen:description="satellite zenith angle at the center of the FOV";
                string sat_zen:AIRS_HDF_name="satzen";

        float sat_azi(atrack, xtrack, fov);
                float sat_azi:valid_range=0.0,  360.0;
                string sat_azi:long_name="satellite azimuth angle";
                string sat_azi:coordinates="lon lat";
                float sat_azi:_FillValue=9.9692099683868690e+36f;
                string sat_azi:coverage_content_type="referenceInformation";
                string sat_azi:standard_name="sensor_azimuth_angle";
                string sat_azi:units="degree";
                string sat_azi:description="satellite azimuth angle at the center of the FOV
(clockwise from North)";
                string sat_azi:AIRS_HDF_name="satazi";

        float sat_range(atrack, xtrack, fov);
                float sat_range:valid_range=1.0e5,  1.0e7;
                string sat_range:long_name="satellite range";
```

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

        ubyte asc_flag(atrack);
                ubyte asc_flag:valid_range=0,  1;
                string asc_flag:long_name="ascending orbit flag";
                string asc_flag:coordinates="subsat_lon subsat_lat";
                ubyte asc_flag:_FillValue=255ub;
                ubyte asc_flag:flag_values=0,  1;
                string asc_flag:coverage_content_type="referenceInformation";
                string asc_flag:description="ascending orbit flag: 1 if ascending, 0 descending";
                string asc_flag:AIRS_HDF_name="scan_node_type";
                string asc_flag:flag_meanings="descending ascending";

        float subsat_lat(atrack);  // standard_name platform_latitude is under review for a
future CF version
                float subsat_lat:valid_range=-90.0,  90.0;
                string subsat_lat:long_name="sub-satellite latitude";
                float subsat_lat:_FillValue=9.9692099683868690e+36f;
                string subsat_lat:coverage_content_type="referenceInformation";
                string subsat_lat:standard_name="latitude";
                string subsat_lat:units="degrees_north";
                string subsat_lat:description="sub-satellite latitude at scan_mid_time";
                string subsat_lat:AIRS_HDF_name="sat_lat";

        float subsat_lon(atrack);  // standard_name platform_longitude is under review for a
future CF version
                float subsat_lon:valid_range=-180.0,  180.0;
                string subsat_lon:long_name="sub-satellite longitude";
                float subsat_lon:_FillValue=9.9692099683868690e+36f;
                string subsat_lon:coverage_content_type="referenceInformation";
                string subsat_lon:standard_name="longitude";
                string subsat_lon:units="degrees_east";
                string subsat_lon:description="sub-satellite longitude at scan_mid_time";
                string subsat_lon:AIRS_HDF_name="sat_lon";

        double scan_mid_time(atrack);
                double scan_mid_time:valid_range=-2934835217.0,  3376598410.0;
                string scan_mid_time:long_name="midscan TAI93";
                string scan_mid_time:coordinates="subsat_lon subsat_lat";
                double scan_mid_time:_FillValue=9.9692099683868690e+36;
                string scan_mid_time:coverage_content_type="referenceInformation";
                string scan_mid_time:standard_name="time";
                string scan_mid_time:units="seconds since 1993-01-01 00:00";
                string scan_mid_time:description="TAI93 at  middle of earth scene scans";
                string scan_mid_time:AIRS_HDF_name="nadirTAI";

        float sat_alt(atrack);  // standard_name platform_altitude is under review for a future
CF version
                float sat_alt:valid_range=1.0e5,  1.0e6;
                string sat_alt:long_name="satellite altitude";
                string sat_alt:coordinates="subsat_lon subsat_lat";
                float sat_alt:_FillValue=9.9692099683868690e+36f;
                string sat_alt:coverage_content_type="referenceInformation";
                string sat_alt:standard_name="altitude";
                string sat_alt:units="m";
                string sat_alt:description="satellite altitude with respect to earth model at
scan_mid_time";
                string sat_alt:AIRS_HDF_name="satheight";

        float sat_pos(atrack, spatial);
                string sat_pos:long_name="satellite position";
                string sat_pos:coordinates="subsat_lon subsat_lat spatial_lbl";
                float sat_pos:_FillValue=9.9692099683868690e+36f;
                string sat_pos:coverage_content_type="referenceInformation";
                string sat_pos:units="m";
                string sat_pos:description="satellite ECR position at scan_mid_time";
```

```
        float sat_vel(atrack, spatial);
                string sat_vel:long_name="satellite velocity";
                string sat_vel:coordinates="subsat_lon subsat_lat spatial_lbl";
                float sat_vel:_FillValue=9.9692099683868690e+36f;
                string sat_vel:coverage_content_type="referenceInformation";
                string sat_vel:units="m s-1";
                string sat_vel:description="satellite ECR velocity at scan_mid_time";

        float sat_att(atrack, attitude);
                float sat_att:valid_range=-180.0,  180.0;
                string sat_att:long_name="satellite attitude";
                string sat_att:coordinates="subsat_lon subsat_lat attitude_lbl";
                float sat_att:_FillValue=9.9692099683868690e+36f;
                string sat_att:coverage_content_type="referenceInformation";
                string sat_att:units="degree";
                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 local_solar_time(atrack, xtrack, fov);
                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";
                float local_solar_time:_FillValue=9.9692099683868690e+36f;
                string local_solar_time:coverage_content_type="referenceInformation";
                string local_solar_time:units="hours";
                string local_solar_time:description="local apparent solar time in hours from
midnight";

        float mean_anom_wrt_equat(atrack);
                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";
                float mean_anom_wrt_equat:_FillValue=9.9692099683868690e+36f;
                string mean_anom_wrt_equat:coverage_content_type="referenceInformation";
                string mean_anom_wrt_equat:units="degree";
                string mean_anom_wrt_equat:description="spacecraft mean anomaly measured with
respect to the ascending node";

        float sat_sol_zen(atrack);
                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";
                float sat_sol_zen:_FillValue=9.9692099683868690e+36f;
                string sat_sol_zen:coverage_content_type="referenceInformation";
                string sat_sol_zen:units="degree";
                string sat_sol_zen:description="solar zenith angle at the satellite";

        float sat_sol_azi(atrack);
                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";
                float sat_sol_azi:_FillValue=9.9692099683868690e+36f;
                string sat_sol_azi:coverage_content_type="referenceInformation";
                string sat_sol_azi:units="degree";
                string sat_sol_azi:description="solar azimuth angle at the satellite (clockwise
from North)";

        float asc_node_lon;
                float asc_node_lon:valid_range=-180.0,  180.0;
                string asc_node_lon:long_name="ascending node";
                float asc_node_lon:_FillValue=9.9692099683868690e+36f;
                string asc_node_lon:coverage_content_type="referenceInformation";
                string asc_node_lon:units="degrees_east";
                string asc_node_lon:description="Longitude of the last ascending node of
spacecraft orbit before time_coverage_end.";
```

```
                string asc_node_lon:AIRS_HDF_name="eq_x_longitude";

        double asc_node_tai93;
                double asc_node_tai93:valid_range=-2934835217.0,  3376598410.0;
                string asc_node_tai93:long_name="ascending node time";
                double asc_node_tai93:_FillValue=9.9692099683868690e+36;
                string asc_node_tai93:coverage_content_type="referenceInformation";
                string asc_node_tai93:units="seconds since 1993-01-01 00:00";
                string asc_node_tai93:description="TAI93 time of the last ascending node of
spacecraft orbit before time_coverage_end.";
                string asc_node_tai93:AIRS_HDF_name="eq_x_tai";

        float asc_node_local_solar_time;
                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";
                float asc_node_local_solar_time:_FillValue=9.9692099683868690e+36f;
                string asc_node_local_solar_time:coverage_content_type="referenceInformation";
                string asc_node_local_solar_time:units="hours";
                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 solar_beta_angle;
                float solar_beta_angle:valid_range=-90.0,  90.0;
                string solar_beta_angle:long_name="beta angle";
                float solar_beta_angle:_FillValue=9.9692099683868690e+36f;
                string solar_beta_angle:coverage_content_type="referenceInformation";
                string solar_beta_angle:units="degree";
                string solar_beta_angle:description="Beta angle for the spacecraft orbit,
determining the percentage of the orbit that the spacecraft is in direct sunlight.";

        string attitude_lbl(attitude);
                string attitude_lbl:long_name="rotational direction";
                string attitude_lbl:coverage_content_type="auxiliaryInformation";
                string attitude_lbl:description="list of rotational directions (roll, pitch,
yaw)";

        string spatial_lbl(spatial);
                string spatial_lbl:long_name="spatial direction";
                string spatial_lbl:coverage_content_type="auxiliaryInformation";
                string spatial_lbl:description="list of spatial directions (X, Y, Z)";

        string utc_tuple_lbl(utc_tuple);
                string utc_tuple_lbl:long_name="UTC date/time parts";
                string utc_tuple_lbl:coverage_content_type="auxiliaryInformation";
                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";

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

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

```
                string rad_lw_qc:flag_meanings="Best Good Do_Not_Use";

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

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

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

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

                int cal_qualflag(atrack, xtrack, fov);
                string cal_qualflag:long_name="L1B quality flags";
                string cal_qualflag:coordinates="lon lat";
                int cal_qualflag:_FillValue=-2147483647;
                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;
                string cal_qualflag:coverage_content_type="qualityInformation";
                string cal_qualflag:description="per-observation L1B product quality";
                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
l1a_bit_trim_mismatch l1a_eight_sec_missing";

                int cal_lw_qualflag(atrack, xtrack, fov);
                string cal_lw_qualflag:long_name="LW quality flags";
                string cal_lw_qualflag:coordinates="lon lat";
                int cal_lw_qualflag:_FillValue=-2147483647;
                int cal_lw_qualflag:flag_masks=3,  3,  12,  12,  48,  48,
```

```
                                                        64,  128,  256,  512,  1024;
                int cal_lw_qualflag:flag_values=1,  2,  4,  8,  16,
                                                        32,  64,  128,  256,  512,  1024;
                string cal_lw_qualflag:coverage_content_type="qualityInformation";
                string cal_lw_qualflag:description="per-observation L1B LW product quality";
                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 l1a_missing_es ict_igm_outlier es_igm_spike_detect";

                int cal_mw_qualflag(atrack, xtrack, fov);
                string cal_mw_qualflag:long_name="MW quality flags";
                string cal_mw_qualflag:coordinates="lon lat";
                int cal_mw_qualflag:_FillValue=-2147483647;
                int cal_mw_qualflag:flag_masks=3,  3,  12,  12,  48,  48,
                                                        64,  128,  256,  512,  1024;
                int cal_mw_qualflag:flag_values=1,  2,  4,  8,  16,
                                                        32,  64,  128,  256,  512,  1024;
                string cal_mw_qualflag:coverage_content_type="qualityInformation";
                string cal_mw_qualflag:description="per-observation L1B MW product quality";
                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 l1a_missing_es ict_igm_outlier es_igm_spike_detect";

                int cal_sw_qualflag(atrack, xtrack, fov);
                string cal_sw_qualflag:long_name="SW quality flags";
                string cal_sw_qualflag:coordinates="lon lat";
                int cal_sw_qualflag:_FillValue=-2147483647;
                int cal_sw_qualflag:flag_masks=3,  3,  12,  12,  48,  48,
                                                        64,  128,  256,  512,  1024;
                int cal_sw_qualflag:flag_values=1,  2,  4,  8,  16,
                                                        32,  64,  128,  256,  512,  1024;
                string cal_sw_qualflag:coverage_content_type="qualityInformation";
                string cal_sw_qualflag:description="per-observation L1B SW product quality";
                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 l1a_missing_es ict_igm_outlier es_igm_spike_detect";

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

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

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

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

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

```
                string for_num:coverage_content_type="auxiliaryInformation";
                string for_num:units="1";
                string for_num:description="field of regard number";

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

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

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

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

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  {
        dimensions:
        sweep = 2;  // scan sweep direction: {forward, reverse}

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

                float rad_imag_lw(atrack, xtrack, fov, wnum_lw);
                        string rad_imag_lw:long_name="longwave imaginary spectral radiance";
                        string rad_imag_lw:coordinates="lon lat";
```

```
                        float rad_imag_lw:_FillValue=9.9692099683868690e+36f;
                        string rad_imag_lw:coverage_content_type="qualityInformation";
                        string
rad_imag_lw:standard_name="toa_outgoing_radiance_per_unit_wavenumber";
                        string rad_imag_lw:units="mW/(m2 sr cm-1)";
                        string rad_imag_lw:description="longwave imaginary spectral radiance";

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

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

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

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

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

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

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

                short spectral_fold_point_sw;
                        string spectral_fold_point_sw:long_name="shortwave spectral folding
index";
                        short spectral_fold_point_sw:_FillValue=-32767s;
```

```
                        string
spectral_fold_point_sw:coverage_content_type="auxiliaryInformation";
                        string spectral_fold_point_sw:units="1";
                        string spectral_fold_point_sw:description="one-based index for unfolding
uncalibrated shortwave spectrum into ascending wavenumbers";

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

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

                double pga_gain_lw(fov);
                        string pga_gain_lw:long_name="longwave PGA gain";
                        double pga_gain_lw:_FillValue=9.9692099683868690e+36;
                        string pga_gain_lw:coverage_content_type="auxiliaryInformation";
                        string pga_gain_lw:units="1";
                        string pga_gain_lw:description="longwave detector channel PGA electrical
gain";

                double pga_gain_mw(fov);
                        string pga_gain_mw:long_name="midwave PGA gain";
                        double pga_gain_mw:_FillValue=9.9692099683868690e+36;
                        string pga_gain_mw:coverage_content_type="auxiliaryInformation";
                        string pga_gain_mw:units="1";
                        string pga_gain_mw:description="midwave detector channel PGA electrical
gain";

                double pga_gain_sw(fov);
                        string pga_gain_sw:long_name="shortwave PGA gain";
                        double pga_gain_sw:_FillValue=9.9692099683868690e+36;
                        string pga_gain_sw:coverage_content_type="auxiliaryInformation";
                        string pga_gain_sw:units="1";
                        string pga_gain_sw:description="shortwave detector channel PGA electrical
gain";

                ubyte cal_view_sweep_dir(sweep);
                        ubyte cal_view_sweep_dir:valid_range=0, 1;
                        string cal_view_sweep_dir:long_name="sweep direction of FOVs for ICT, DS,
and resp";
                        ubyte cal_view_sweep_dir:_FillValue=255ub;
                        ubyte cal_view_sweep_dir:flag_values=0,  1;
                        string cal_view_sweep_dir:coverage_content_type="auxiliaryInformation";
                        string cal_view_sweep_dir:units="1";
                        string cal_view_sweep_dir:description="sweep direction of FOVs for ICT,
DS, and resp";
                        string cal_view_sweep_dir:flag_meanings="forward reverse";

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

                float ssm_baffle_corr_temp(atrack);
```

```
                        string ssm_baffle_corr_temp:long_name="ICT model, scan baffle temperature
correction";
                        float ssm_baffle_corr_temp:_FillValue=9.9692099683868690e+36f;
                        string ssm_baffle_corr_temp:coverage_content_type="auxiliaryInformation";
                        string ssm_baffle_corr_temp:units="Kelvin";
                        string ssm_baffle_corr_temp:description="ICT radiometric model, modelled
SSM baffle orbital offset";

                float earth_temp(atrack);
                        string earth_temp:long_name="ICT model, Earth temperature";
                        float earth_temp:_FillValue=9.9692099683868690e+36f;
                        string earth_temp:coverage_content_type="auxiliaryInformation";
                        string earth_temp:units="Kelvin";
                        string earth_temp:description="ICT radiometric model, assumed Earth
temperature term from eng packet";

                float ict_prt1_temp(atrack);
                        string ict_prt1_temp:long_name="ICT PRT1 temperature";
                        float ict_prt1_temp:_FillValue=9.9692099683868690e+36f;
                        string ict_prt1_temp:coverage_content_type="auxiliaryInformation";
                        string ict_prt1_temp:units="Kelvin";
                        string ict_prt1_temp:description="ICT PRT1 temperature";

                float ict_prt2_temp(atrack);
                        string ict_prt2_temp:long_name="ICT PRT2 temperature";
                        float ict_prt2_temp:_FillValue=9.9692099683868690e+36f;
                        string ict_prt2_temp:coverage_content_type="auxiliaryInformation";
                        string ict_prt2_temp:units="Kelvin";
                        string ict_prt2_temp:description="ICT PRT2 temperature";

                float oma_struct_temp_1(atrack);
                        string oma_struct_temp_1:long_name="OMA temperature 1";
                        float oma_struct_temp_1:_FillValue=9.9692099683868690e+36f;
                        string oma_struct_temp_1:coverage_content_type="auxiliaryInformation";
                        string oma_struct_temp_1:units="Kelvin";
                        string oma_struct_temp_1:description="OMA structure temperature 1";

                float oma_struct_temp_2(atrack);
                        string oma_struct_temp_2:long_name="OMA temperature 2";
                        float oma_struct_temp_2:_FillValue=9.9692099683868690e+36f;
                        string oma_struct_temp_2:coverage_content_type="auxiliaryInformation";
                        string oma_struct_temp_2:units="Kelvin";
                        string oma_struct_temp_2:description="OMA structure temperature 2";

                float ssm_scan_mirror_temp(atrack);
                        string ssm_scan_mirror_temp:long_name="scan mirror temperature";
                        float ssm_scan_mirror_temp:_FillValue=9.9692099683868690e+36f;
                        string ssm_scan_mirror_temp:coverage_content_type="auxiliaryInformation";
                        string ssm_scan_mirror_temp:units="Kelvin";
                        string ssm_scan_mirror_temp:description="SSM scan mirror temperature";

                float bs_temp(atrack);
                        string bs_temp:long_name="beamsplitter temperature";
                        float bs_temp:_FillValue=9.9692099683868690e+36f;
                        string bs_temp:coverage_content_type="auxiliaryInformation";
                        string bs_temp:units="Kelvin";
                        string bs_temp:description="beamsplitter temperature";

                float ssm_baffle_temp(atrack);
                        string ssm_baffle_temp:long_name="SSM scan mirror baffle temperature";
                        float ssm_baffle_temp:_FillValue=9.9692099683868690e+36f;
                        string ssm_baffle_temp:coverage_content_type="auxiliaryInformation";
                        string ssm_baffle_temp:units="Kelvin";
                        string ssm_baffle_temp:description="SSM scan mirror baffle temperature
including modelled orbital offset";

                float resp_mean_mag_lw(sweep, fov, wnum_lw);
                        string resp_mean_mag_lw:long_name="longwave mean magnitude responsivity";
                        float resp_mean_mag_lw:_FillValue=9.9692099683868690e+36f;
                        string resp_mean_mag_lw:coverage_content_type="auxiliaryInformation";
                        string resp_mean_mag_lw:units="1 / (mW/(m2 sr cm-1))";
```

```
                        string resp_mean_mag_lw:description="longwave granule mean of magnitude
responsivity";

                float resp_mean_mag_mw(sweep, fov, wnum_mw);
                        string resp_mean_mag_mw:long_name="midwave mean magnitude responsivity";
                        float resp_mean_mag_mw:_FillValue=9.9692099683868690e+36f;
                        string resp_mean_mag_mw:coverage_content_type="auxiliaryInformation";
                        string resp_mean_mag_mw:units="1 / (mW/(m2 sr cm-1))";
                        string resp_mean_mag_mw:description="midwave granule mean of magnitude
responsivity";

                float resp_mean_mag_sw(sweep, fov, wnum_sw);
                        string resp_mean_mag_sw:long_name="shortwave mean magnitude responsivity";
                        float resp_mean_mag_sw:_FillValue=9.9692099683868690e+36f;
                        string resp_mean_mag_sw:coverage_content_type="auxiliaryInformation";
                        string resp_mean_mag_sw:units="1 / (mW/(m2 sr cm-1))";
                        string resp_mean_mag_sw:description="shortwave granule mean of magnitude
responsivity";

                float resp_sdev_mag_lw(sweep, fov, wnum_lw);
                        string resp_sdev_mag_lw:long_name="longwave std dev magnitude
responsivity";
                        float resp_sdev_mag_lw:_FillValue=9.9692099683868690e+36f;
                        string resp_sdev_mag_lw:coverage_content_type="auxiliaryInformation";
                        string resp_sdev_mag_lw:units="1 / (mW/(m2 sr cm-1))";
                        string resp_sdev_mag_lw:description="longwave granule std dev of magnitude
responsivity";

                float resp_sdev_mag_mw(sweep, fov, wnum_mw);
                        string resp_sdev_mag_mw:long_name="midwave std dev magnitude
responsivity";
                        float resp_sdev_mag_mw:_FillValue=9.9692099683868690e+36f;
                        string resp_sdev_mag_mw:coverage_content_type="auxiliaryInformation";
                        string resp_sdev_mag_mw:units="1 / (mW/(m2 sr cm-1))";
                        string resp_sdev_mag_mw:description="midwave granule std dev of magnitude
responsivity";

                float resp_sdev_mag_sw(sweep, fov, wnum_sw);
                        string resp_sdev_mag_sw:long_name="shortwave std dev magnitude
responsivity";
                        float resp_sdev_mag_sw:_FillValue=9.9692099683868690e+36f;
                        string resp_sdev_mag_sw:coverage_content_type="auxiliaryInformation";
                        string resp_sdev_mag_sw:units="1 / (mW/(m2 sr cm-1))";
                        string resp_sdev_mag_sw:description="shortwave granule std dev of
magnitude responsivity";

                float ict_real_mean_lw(sweep, fov, wnum_lw);
                        string ict_real_mean_lw:long_name="longwave mean ICT real raw spectra";
                        float ict_real_mean_lw:_FillValue=9.9692099683868690e+36f;
                        string ict_real_mean_lw:coverage_content_type="auxiliaryInformation";
                        string ict_real_mean_lw:units="1";
                        string ict_real_mean_lw:description="longwave mean ICT raw spectra real
component";

                float ict_imag_mean_lw(sweep, fov, wnum_lw);
                        string ict_imag_mean_lw:long_name="longwave mean ICT imag raw spectra";
                        float ict_imag_mean_lw:_FillValue=9.9692099683868690e+36f;
                        string ict_imag_mean_lw:coverage_content_type="auxiliaryInformation";
                        string ict_imag_mean_lw:units="1";
                        string ict_imag_mean_lw:description="longwave mean ICT raw spectra
imaginary component";

                float ict_real_mean_mw(sweep, fov, wnum_mw);
                        string ict_real_mean_mw:long_name="midwave mean ICT real raw spectra";
                        float ict_real_mean_mw:_FillValue=9.9692099683868690e+36f;
                        string ict_real_mean_mw:coverage_content_type="auxiliaryInformation";
                        string ict_real_mean_mw:units="1";
                        string ict_real_mean_mw:description="midwave mean ICT raw spectra real
component";

                float ict_imag_mean_mw(sweep, fov, wnum_mw);
```

```
                        string ict_imag_mean_mw:long_name="midwave mean ICT imag raw spectra";
                        float ict_imag_mean_mw:_FillValue=9.9692099683868690e+36f;
                        string ict_imag_mean_mw:coverage_content_type="auxiliaryInformation";
                        string ict_imag_mean_mw:units="1";
                        string ict_imag_mean_mw:description="midwave mean ICT raw spectra
imaginary component";

                float ict_real_mean_sw(sweep, fov, wnum_sw);
                        string ict_real_mean_sw:long_name="shortwave mean ICT real raw spectra";
                        float ict_real_mean_sw:_FillValue=9.9692099683868690e+36f;
                        string ict_real_mean_sw:coverage_content_type="auxiliaryInformation";
                        string ict_real_mean_sw:units="1";
                        string ict_real_mean_sw:description="shortwave mean ICT raw spectra real
component";

                float ict_imag_mean_sw(sweep, fov, wnum_sw);
                        string ict_imag_mean_sw:long_name="shortwave mean ICT imag raw spectra";
                        float ict_imag_mean_sw:_FillValue=9.9692099683868690e+36f;
                        string ict_imag_mean_sw:coverage_content_type="auxiliaryInformation";
                        string ict_imag_mean_sw:units="1";
                        string ict_imag_mean_sw:description="shortwave mean ICT raw spectra
imaginary component";

                float space_real_mean_lw(sweep, fov, wnum_lw);
                        string space_real_mean_lw:long_name="longwave mean space view real raw
spectra";
                        float space_real_mean_lw:_FillValue=9.9692099683868690e+36f;
                        string space_real_mean_lw:coverage_content_type="auxiliaryInformation";
                        string space_real_mean_lw:units="1";
                        string space_real_mean_lw:description="longwave mean space view raw
spectra real component";

                float space_imag_mean_lw(sweep, fov, wnum_lw);
                        string space_imag_mean_lw:long_name="longwave mean space view imag raw
spectra";
                        float space_imag_mean_lw:_FillValue=9.9692099683868690e+36f;
                        string space_imag_mean_lw:coverage_content_type="auxiliaryInformation";
                        string space_imag_mean_lw:units="1";
                        string space_imag_mean_lw:description="longwave mean space view raw
spectra imaginary component";

                float space_real_mean_mw(sweep, fov, wnum_mw);
                        string space_real_mean_mw:long_name="midwave mean space view real raw
spectra";
                        float space_real_mean_mw:_FillValue=9.9692099683868690e+36f;
                        string space_real_mean_mw:coverage_content_type="auxiliaryInformation";
                        string space_real_mean_mw:units="1";
                        string space_real_mean_mw:description="midwave mean space view raw spectra
real component";

                float space_imag_mean_mw(sweep, fov, wnum_mw);
                        string space_imag_mean_mw:long_name="midwave mean space view imag raw
spectra";
                        float space_imag_mean_mw:_FillValue=9.9692099683868690e+36f;
                        string space_imag_mean_mw:coverage_content_type="auxiliaryInformation";
                        string space_imag_mean_mw:units="1";
                        string space_imag_mean_mw:description="midwave mean space view raw spectra
imaginary component";

                float space_real_mean_sw(sweep, fov, wnum_sw);
                        string space_real_mean_sw:long_name="shortwave mean space view real raw
spectra";
                        float space_real_mean_sw:_FillValue=9.9692099683868690e+36f;
                        string space_real_mean_sw:coverage_content_type="auxiliaryInformation";
                        string space_real_mean_sw:units="1";
                        string space_real_mean_sw:description="shortwave mean space view raw
spectra real component";

                float space_imag_mean_sw(sweep, fov, wnum_sw);
                        string space_imag_mean_sw:long_name="shortwave mean space view imag raw
spectra";
```

```
                        float space_imag_mean_sw:_FillValue=9.9692099683868690e+36f;
                        string space_imag_mean_sw:coverage_content_type="auxiliaryInformation";
                        string space_imag_mean_sw:units="1";
                        string space_imag_mean_sw:description="shortwave mean space view raw
spectra imaginary component";

                float earth_vdc_lw(atrack, xtrack, fov);
                        string earth_vdc_lw:long_name="longwave Earth view DC level";
                        string earth_vdc_lw:coordinates="lon lat";
                        float earth_vdc_lw:_FillValue=9.9692099683868690e+36f;
                        string earth_vdc_lw:coverage_content_type="auxiliaryInformation";
                        string earth_vdc_lw:units="V";
                        string earth_vdc_lw:description="longwave Earth view DC level";

                float earth_vdc_mw(atrack, xtrack, fov);
                        string earth_vdc_mw:long_name="midwave Earth view DC level";
                        string earth_vdc_mw:coordinates="lon lat";
                        float earth_vdc_mw:_FillValue=9.9692099683868690e+36f;
                        string earth_vdc_mw:coverage_content_type="auxiliaryInformation";
                        string earth_vdc_mw:units="V";
                        string earth_vdc_mw:description="midwave Earth view DC level";

                float earth_vdc_sw(atrack, xtrack, fov);
                        string earth_vdc_sw:long_name="shortwave Earth view DC level";
                        string earth_vdc_sw:coordinates="lon lat";
                        float earth_vdc_sw:_FillValue=9.9692099683868690e+36f;
                        string earth_vdc_sw:coverage_content_type="auxiliaryInformation";
                        string earth_vdc_sw:units="V";
                        string earth_vdc_sw:description="shortwave Earth view DC level";

                float ict_vdc_lw(sweep, fov);
                        string ict_vdc_lw:long_name="longwave ICT DC level";
                        float ict_vdc_lw:_FillValue=9.9692099683868690e+36f;
                        string ict_vdc_lw:coverage_content_type="auxiliaryInformation";
                        string ict_vdc_lw:units="V";
                        string ict_vdc_lw:description="granule mean longwave ICT DC level";

                float ict_vdc_mw(sweep, fov);
                        string ict_vdc_mw:long_name="midwave ICT DC level";
                        float ict_vdc_mw:_FillValue=9.9692099683868690e+36f;
                        string ict_vdc_mw:coverage_content_type="auxiliaryInformation";
                        string ict_vdc_mw:units="V";
                        string ict_vdc_mw:description="granule mean midwave ICT DC level";

                float ict_vdc_sw(sweep, fov);
                        string ict_vdc_sw:long_name="shortwave ICT DC level";
                        float ict_vdc_sw:_FillValue=9.9692099683868690e+36f;
                        string ict_vdc_sw:coverage_content_type="auxiliaryInformation";
                        string ict_vdc_sw:units="V";
                        string ict_vdc_sw:description="granule mean shortwave ICT DC level";

                float space_vdc_lw(sweep, fov);
                        string space_vdc_lw:long_name="longwave space view DC level";
                        float space_vdc_lw:_FillValue=9.9692099683868690e+36f;
                        string space_vdc_lw:coverage_content_type="auxiliaryInformation";
                        string space_vdc_lw:units="V";
                        string space_vdc_lw:description="granule mean longwave space view DC
level";

                float space_vdc_mw(sweep, fov);
                        string space_vdc_mw:long_name="midwave space view DC level";
                        float space_vdc_mw:_FillValue=9.9692099683868690e+36f;
                        string space_vdc_mw:coverage_content_type="auxiliaryInformation";
                        string space_vdc_mw:units="V";
                        string space_vdc_mw:description="granule mean midwave space view DC
level";

                float space_vdc_sw(sweep, fov);
                        string space_vdc_sw:long_name="shortwave space view DC level";
                        float space_vdc_sw:_FillValue=9.9692099683868690e+36f;
                        string space_vdc_sw:coverage_content_type="auxiliaryInformation";
```

```
                        string space_vdc_sw:units="V";
                        string space_vdc_sw:description="granule mean shortwave space view DC
level";

                short ict_moving_avg_width_lw(atrack, sweep, fov);
                        string ict_moving_avg_width_lw:long_name="longwave ICT moving average
size";
                        short ict_moving_avg_width_lw:_FillValue=-32767s;
                        string
ict_moving_avg_width_lw:coverage_content_type="auxiliaryInformation";
                        string ict_moving_avg_width_lw:units="1";
                        string ict_moving_avg_width_lw:description="longwave ICT moving average
size";

                short ict_moving_avg_width_mw(atrack, sweep, fov);
                        string ict_moving_avg_width_mw:long_name="midwave ICT moving average
size";
                        short ict_moving_avg_width_mw:_FillValue=-32767s;
                        string
ict_moving_avg_width_mw:coverage_content_type="auxiliaryInformation";
                        string ict_moving_avg_width_mw:units="1";
                        string ict_moving_avg_width_mw:description="midwave ICT moving average
size";

                short ict_moving_avg_width_sw(atrack, sweep, fov);
                        string ict_moving_avg_width_sw:long_name="shortwave ICT moving average
size";
                        short ict_moving_avg_width_sw:_FillValue=-32767s;
                        string
ict_moving_avg_width_sw:coverage_content_type="auxiliaryInformation";
                        string ict_moving_avg_width_sw:units="1";
                        string ict_moving_avg_width_sw:description="shortwave ICT moving average
size";

                short space_moving_avg_width_lw(atrack, sweep, fov);
                        string space_moving_avg_width_lw:long_name="longwave space view moving
average size";
                        short space_moving_avg_width_lw:_FillValue=-32767s;
                        string
space_moving_avg_width_lw:coverage_content_type="auxiliaryInformation";
                        string space_moving_avg_width_lw:units="1";
                        string space_moving_avg_width_lw:description="longwave space view moving
average size";

                short space_moving_avg_width_mw(atrack, sweep, fov);
                        string space_moving_avg_width_mw:long_name="midwave space view moving
average size";
                        short space_moving_avg_width_mw:_FillValue=-32767s;
                        string
space_moving_avg_width_mw:coverage_content_type="auxiliaryInformation";
                        string space_moving_avg_width_mw:units="1";
                        string space_moving_avg_width_mw:description="midwave space view moving
average size";

                short space_moving_avg_width_sw(atrack, sweep, fov);
                        string space_moving_avg_width_sw:long_name="shortwave space view moving
average size";
                        short space_moving_avg_width_sw:_FillValue=-32767s;
                        string
space_moving_avg_width_sw:coverage_content_type="auxiliaryInformation";
                        string space_moving_avg_width_sw:units="1";
                        string space_moving_avg_width_sw:description="shortwave space view moving
average size";

        } // aux
} // j1_l1b_cris_fsr
```

Appendix C: Abbreviations Used in Variable and Dimension Names

abbreviation	meaning
alt	altitude
ang	angle
anom	anomaly
asc	ascending
atrack	along-track
att	attitude
aux	auxiliary
avg	average
azi	azimuth
bnds	bounds
bs	beamsplitter
cal	calibration
corr	correction
dir	direction
dist	distance
equat	equator
for	field of regard
fov	field of view
frac	fraction
geo	geolocation
ict	internal calibration target
imag	imaginary
isa	inverse self apodization
lat	latitude

lbl	label
lon	longitude
lw	long-wave
mag	magnitude
max	maximum
mw	mid-wave
nedn	noise equivalent differential radiance
num	number
obs	observation
oma	optical mechanical assembly
opd	optical path difference
pga	programmable gate array
poly	polygon
pos	position
prt	platinum resistance thermometer
qc	quality control
qualflag	quality flag
rad	radiance
resp	responsivity
sat	satellite
sdev	standard deviation
sol	solar
ssm	scene scan mirror
struct	structure
subsat	sub-satellite
sw	short-wave
tai	International Atomic Time

temp	temperature
utc	Coordinated Universal Time
vdc	DC voltage
vel	velocity
wlen	wavelength
wnum	wavenumber
wrt	with respect to
xtrack	cross-track
zen	zenith