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

# Data Product User Guide for S-NPP Sounder SIPS CHART and CLIMCAPS CrIS and ATMS Level-3 Products

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Product Version 1.0

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# Revision History

| ***Revision Date*** | ***Changes*** | ***Author*** |
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| 2019-09-09 | Initial Release | Evan Manning |

# 1.0 Introduction

This document provides basic information for using Version 1 Level-3 products from the Cross-track Infrared and Microwave Sounding Suite (CrIMSS) instruments on the Suomi-NPP spacecraft. The CrIMSS instrument suite consists of the Cross-track Infrared Sounder (CrIS) infrared sounder and the Advanced Technology Microwave Sounder (ATMS) microwave sounder.

The products result from two retrieval algorithms: Climate Heritage AIRS Retrieval Technique (CHART) and Community Long-term Infrared Microwave Coupled Atmospheric Product System (CLIMCAPS). The different approaches of these two algorithms are briefly described in Section 2.2 and Appendix A.

The Level-3 retrieval products from each algorithm contains a variety of geophysical parameters derived from the CrIMSS data, including temperature profiles, water vapor, ozone, clouds, and surface properties, all gridded 1x1 degree latitude/longitude. There are one-day and monthly products. For CHART, these products are produced with different quality control strategies. These products have been annotated with both file and variable level attributes to fully describe their contents.

## 1.1 Overview of Sounder SIPS

The Suomi-National Polar-Orbiting Partnership (S-NPP) Sounder SIPS, is one of six SIPSs formed by NASA to provide the processing of level 0 data through level 1, level 2 and level 3 from the Suomi NPP (previously known as NPP) satellite. The Suomi-NPP satellite is managed by the National Polar-orbiting Partnership (NPP) which includes elements from NASA, NOAA and DoD. Details about the S-NPP Mission can be found at: http://npp.gsfc.nasa.gov/index.html.

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

## 1.2 Mission Description

The S-NPP satellite was launched on October 28, 2011 from Vandenburg Air Force Base in California 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 [Reference 3]. SNPP is the first in a series of next generation U.S. weather satellites of the Joint Polar Satellite System (JPSS). CrIMSS (CrIS and ATMS) are two of the five instruments onboard the S-NPP satellite. The

other instruments are: Clouds and the Earth's Radiant Energy System (CERES), Ozone Mapping and Profiler Suite (OMPS) and Visible Infrared Imaging Radiometer Suite (VIIRS).

Table 1.2.2 contains a summary of platform parameters.

**Table 1.2.2 Approximate S-NPP orbital parameters.**

| Platform | Alt | Orbit Incl. (°) | Equator X Time | Period | Repeat Orbits | Repeat Days | Launch |
|---|---|---|---|---|---|---|---|
| **S-NPP** | 824 | 98.7 | 13:30* | 101 | 228 | 16 | 28 Oct 2011 |

CrIS and ATMS are designed to be used together as CrIMSS, the Cross-track Infrared and Microwave Sounding Suite. Both algorithms used here combine infrared (IR) data from CrIS with microwave (MW) data from ATMS in a single IR+MW retrieval.

# 1.3 CrIS Instrument Description

The Cross-track Infrared Sounder (CrIS) is a Fourier Transform Spectrometer (FTS) 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, 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-degree 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 direction 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.

These products were produced using version 1 of the CrIS Level-1B product in Normal Spectral Resolution (NSR).

# 1.4 ATMS Instrument Description

ATMS is a 22-channel cross-track scanning microwave sounder providing both temperature and humidity soundings. Table 1.4.1 contains a summary of the ATMS instrument parameters.

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

**Table 1.4.1 ATMS instrument parameters.**

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

# 1.5 Data Disclaimer

Version 1.0 CrIMSS Level-3 data are released to the public as is. Every effort has been made to properly represent the data which this document describes.

# 1.6 Where to find the Product

The CrIMSS Level-3 products can be found at and downloaded from the Goddard Distributed Active Archive Center (GDAAC). There you will find additional information and documentation about this product and other products of interest. Search "Suomi-NPP CrIS" (with quotes) under Data Collections.

https://disc.gsfc.nasa.gov

# 1.7 Contact Information

For information, questions or concerns with this CrIMSS Level-3 data set, please send your questions to: sounder.sips@jpl.nasa.gov.

# 1.8 References

If links do not resolve, copy the url to a browser.

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

2. NASA SNPP Cross Track Infrared Sounder (CrIS) Level 1B Quality Flags Description Document

3. Data Product User Guide for Suomi-National Polar-Orbiting Partnership (S-NPP) Sounder Science Investigator-led Processing System (SIPS) Advanced Technology Microwave Sounder (ATMS) Level 1B Products

4. CHART Level-2 ATBD
https://docserver.gesdisc.eosdis.nasa.gov/public/project/SNPP/SNPP_limited_edition/SNPP.CrIMSS.CHART_V1.ATBD.pdf

5. CLIMCAPS Level-2 ATBD
https://docserver.gesdisc.eosdis.nasa.gov/public/project/SNPP/SNPP_limited_edition/SNPP.CrIMSS.CLIMCAPS_V1.ATBD.pdf

6. NetCDF Climate and Forecast (CF) Metadata Conventions, Version 1.7,
http://cfconventions.org/Data/cf-conventions/cf-conventions-1.7/cf-conventions.html

7. MERRA-2 https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/

# 2.0 Level-3 Product Overview

Level-2 products are created from CrIS and ATMS Level-1B observations using two algorithms: CHART and CLIMCAPS. The results of these algorithms are then collected into 1-day and 1-month gridded Level-3 files.

## 2.1 Product Granulation

The Level-3 products are produced for every day and for every month. Each daily file has a nominal date, but actually contains data extending beyond the boundaries of the nominal date. Data is separated by the "orbit_pass" dimension into observations taken while the spacecraft is moving northwards (ascending) and while it is moving southwards. For non-polar regions, ascending data is daytime and descending is nighttime, but at the poles the sun may be over the horizon for neither or both. The first element in the orbit_pass dimension is the ascending element, with data taken around its nominal 13.5 hour equatorial orbit pass time (1:30 PM local time). The second element is the descending element, with data taken around 1.5 hours or 1:30 AM local time. Data is divided among days such that each orbit_pass element for each day contains data for longitudes [-180, 180], and images from successive days could be stitched together. Data in the same location for the two orbit_passes is offset by 12 hours. Variables orbit_pass, obs_time_tai93, obs_time_tai93_bnds, and obt_time_utc can help with interpretation.

Monthly Level-3 products are summaries of the data from the 28-31 daily Level-3 products in a calendar month.

## 2.2 Level-2 Algorithm Background

The Sounder SIPS Level-3 data products are a product of processing NASA Level 0 data through Level 1A, Level 1B, Level-2, and Level-3. For a definition of the NASA Data Processing Levels go to: https://earthdata.nasa.gov/earth-science-data-systems-program/policies/data-information-policy/data-levels

Both CHART and CLIMCAPS are based on the AIRS Level-2 team algorithm [ https://disc.gsfc.nasa.gov/information/documents?title=AIRS%20Documentation ]. CHART v6.46 remains very close to the AIRS v6 algorithm, with changes consistent with changes towards the AIRS v7 algorithm [ https://airs.jpl.nasa.gov/system/presentations/files/321_Susskind_AIRS_CrIS_Retrieval.pdf ]. CLIMCAPS v1.01 is based on an earlier AIRS team algorithm. It replaces the SCCNN neural net first guess with MERRA2 (see Section 3.11, GFS was accidentally used as the first guess), streamlines the algorithm flow to use a single pass, and uses optimal estimation in the

individual species retrieval steps [ https://airs.jpl.nasa.gov/system/presentations/files/381_StatusBarnet.pdf ].

Technical details of the Level-2 processing steps and calibrations can be found in the Algorithm Theoretical Basis Documents (ATBDs). See references.

## 2.3 Level-3 Algorithm Summary

The Level-3 daily algorithm selects which observations belong to each grid cell, determines which observations pass quality control, and averages the accepted observations.

Level-2 observations are determined to be ascending or descending according to the "asc_flag" Level-2 variable.

Although CHART and CLIMCAPS perform Field-of-Regard (FOR) based retrievals, with only one retrieved value of most variables per FOR, the data is treated as if this value was separately observed for the central lat/lon of each of the 9 associated Fields-of-View (FOVs).

Level-2 observations are associated with a nominal date according to whether the longitude-adjusted observation time (obs_time_tai93 + 240.0 * fov_lon) is within 12 hours of the appropriate orbit_pass mean time.

Level-2 observations are associated with the 1x1 degree latitude/longitude grid cell in which the {fov_lon, fov_lat} falls.

Quality control can be either "Specific" (QCS) or "Comprehensive" (QCC). QCS products maximize yield of each individual species and level by collecting all cases where the corresponding *_qc value is 0 (best) or 1 (good). QCC products ensure analyses will be consistent across levels and species by including all cases where the whole profile is considered to be quality 0 or 1. For this release there are both QCC and QCS products for CHART but only QCC for CLIMCAPS.

Level-3 monthly products summarize the 28-31 daily products in a calendar month. The mean value from each day is weighted equally, not according to the number of observations contributing, in order to maximize representativeness.

## 2.4 File Format and Structure

The files are in Network Common Data Form, version 4 (NetCDF4/HDF5) format.

The product format takes advantage of the NetCDF4 data model and makes use of groups, dimensions, variables and attributes to fully describe the science data.

## 2.5 Metadata

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

See the full product specifications in Appendix C.

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

## 2.6 File Naming Convention

File naming for Sounder SIPS products will be unique and include the following tokens separated by the delimiter '.' For each token that makes up the filename, there will be an attribute in the data product that it maps to (see Table 2.6.1 Filenaming).

<Sounder_SIPS_ID>.<platform>.<inst_ID>.<granuleID>.<product_granularity>.<product_type>.<variant>.<version>.<production_location>.<prod_timestamp>.<extension>

Where:

- **Sounder_SIPS_ID** as a project identifier <product_name_project> = SNDR
- **platform** <product_name_platform> = SNPP
- **inst_ID** <product_name_instr> = CRIMSS
- **granuleID** (yyyymmdd) <gran_id> nominal start time where:
  - yyyy = year
  - mm = month of year (01-12)
  - dd = day of month (01-31)
- **product_granularity** <product_name_duration> = D01 or M01 (1 day or 1 month)
- **product_type** with an optional identifier for testing <product_type_name_id>
  - L3_CHART_QCC_NSR for CHART products derived from CrIS NSR spectral resolution, accumulated with QCC=Comprehensive QC.
  - L3_CHART_QCS_NSR for CHART products derived from CrIS NSR spectral resolution, accumulated with QCS=Specific QC.
  - L3_CLIMCAPS_QCC_NSR for CLIMCAPS products derived from CrIS NSR spectral resolution, accumulated with QCC=Comprehensive QC..
- **variant** <product_name_variant> = std
- **version** vmm_mm <product_name_version> - eg. v01_32
  - Versioning will be synchronized across Sounder SIPS products

    - Version 1 Level-2 and Level-3 products are derived from version 1 Level-1B products
  - **production_location** <product_name_producer>- J=SIPS at JPL, G=Operations, T=Test, W = CrIS Team at Univ of Wisc
  - **prod_timestamp** so each product has a unique name (yymmddhhmmss) <product_name_timestamp>- 150407123456
  - **Extension** (.nc)

**Table 2.6.1 Product Filenaming**

| Filename token | Attribute name in CDF (mapping) | Format | Value(s) | Notes |
|---|---|---|---|---|
| Sounder_SIPS_ID | product_name_project | | SNDR | |
| platform | product_name_platform | | SNPP | |
| inst_ID | product_name_instr | | CRIMSS | CRIMSS = CrIS + ATMS |
| granuleID | gran_id | yyyymmdd | Nominal start date | |
| product_granularity | product_name_duration | | D01, M01 | 1 day or 1 month |
| product_type | product_name_type_id + optional identifier for uniqueness | L3_<alg>_<prod>_NSR | L3_CHART_QCC_NSR<br>L3_CHART_QCS_NSR<br>L3_CLIMCAPS_QCC_NSR | <alg> is CHART or CLIMCAPS<br><prod> is QCC or QCS<br>_NSR is always present in the v1 release because v1 Level-1B CrIS is only NSR |
| Version | product_name_version | v01_## | | e.g. v01_32 |
| variant | product_name_variant | Freeform text. | std | Used to identify special runs. The default is: std = standard. |
| production_location | product_name_producer | | J: JPL<br>G: GSFC<br>T: Test | |
| prod_timestamp | product_name_timestamp | yymmddhhmmss | | |

Example Filename: Monthly CrIMSS Level-3 products for January 2016:

```
SNDR.SNPP.CRIMSS.20160101.M01.L3_CHART_QCC_NSR.std.v01_32.J.190409202728.nc
SNDR.SNPP.CRIMSS.20160101.M01.L3_CHART_QCS_NSR.std.v01_32.J.190409202718.nc
SNDR.SNPP.CRIMSS.20160101.M01.L3_CLIMCAPS_QCC_NSR.std.v01_32.J.190409202653.nc
```

# 2.8 Time Representation

Observation times are provided in both UTC and TAI93 representations as a convenience to users.

Coordinated Universal Time (UTC) is the international standard for representation of time. UTC times are expressed in human-readable form, as a set of values indicating year, month, day, hour and so on. In the data stream received from the satellite, observation times are represented as UTC.

Timestamps in 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.

# 2.9 Data Holdings

For the initial release of v1 CHART & CLIMCAPS, a test data set of 8 months of data is provided. This data covers the months of {January, April, July, October} of the years 2013 & 2015. This set is designed to allow research and comparisons over a full seasonal cycle and comparisons of different phases of the ENSO cycle.

# 3.0 Data Content

The Level-3 data products are written in netCDF4 format and therefore makes use of groups, dimensions, variables and attributes (global & variable). Every netCDF4 file contains, at a minimum, one root group which is unnamed.

A full profile of the contents of the files is included in Appendix C.

Selected fields are highlighted in this section.

## 3.1 Dimensions

Key dimensions for CHART and CLIMCAPS Level-3 products.

**Table 3.1 Key Dimensions**

| Name | Size | Description |
|---|---|---|
| **lon** | 360 | 1-degree longitude grid |
| **lat** | 180 | 1-degree latitude grid |
| **orbit_pass** | 2 | orbit pass: {Ascending/Day, Descending/Night} |
| **air_pres** | 100 | Fine atmospheric pressure levels for temperature and most gases starting from the top |
| **air_pres_h2o** | 66 | Fine atmospheric pressure levels for water-vapor variables starting from the top |

## 3.2 Global Attributes (metadata)

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

A full definition of the global attributes can be found in Appendix C.

**Table 3.2.2 Key Global Attributes**

| Name | Description |
|---|---|
| **date_created** | The date on which this version of the data was created |
| **identifier_product_doi** | digital signature (DOI) |

## 3.3 Variable Attributes

Each variable has its own associated attributes. Variable attributes are a CF standard and are used to describe the variable in more detail to properly interpret its value.

**Table 3.3: Variable Attributes**

| Attribute | Description |
|---|---|
| **units** | units, for variables that represent physical quantities |
| **_FillValue** | a single sentinel value indicating the data point contains fill instead of valid data |
| **standard_name** | standard name from the CF standard name table, if one exists for the quantity being represented |
| **long_name** | a longer name describing the quantity being represented, suitable for a plot title |
| **description** | a longer description of the quantity being represented |
| **valid_range** | a pair of values indicating the minimum and maximum values to be considered valid |
| **coordinates** | a space-separated list of the names of other variables that are coordinates for this variable |
| **coverage_content_type** | ACDD/ISO field categorizing types of data:<br>• image<br>• thematicClassification<br>• physicalMeasurement<br>• auxillaryInformation<br>• coordinate<br>• modelResult<br>• qualityInformation<br>• referenceInformation<br>https://geo-ide.noaa.gov/wiki/index.php?title=ISO_19115_and_19115-2_CodeList_Dictionaries#MD_CoverageContentTypeCode |
| **ancillary_variables** | a space-separated list of the names of other variables that contain information about this variable |
| **bounds** | defines the extent, for cell variables including obs_time_tai93, lon, lat, and cld_pres_lay |
| **cell_methods** | describes statistical methods used to derive data, for cell variables |

## 3.4 Group Structure

One feature which was added to netCDF4 is the ability to structure files with "groups", which are similar to a directory hierarchy. SounderCDF files are designed so that all of the most commonly needed information is contained in "/", the root group. Subgroups contain more specialized information.

These are the groups:

| Group | Purpose |
|---|---|
| **/ (root)** | Main group, with temperature and water vapor profiles, along with supporting location and quality information |
| **/nobs** | The number of observations for the gridded physical quantities |

## 3.5 Geolocation

These products use a simple latitude/longitude 1x1 degree grid.

Longitudes run from -180 to 180 degrees East, with grid centers at {-179.5, -178.5, …179.5} as recorded in variable "lon". Associated bounds variable lon_bnds gives the boundaries of each cell: { [-180, -179), [-179, -178], … [179, 180)}.

Latitudes run from -90 to 90 degrees North, with grid centers at {-89.5, -88.5, …89.5} as recorded in variable "lat". Associated bounds variable lat_bnds gives the boundaries of each cell: { [-90, -89), [-89, -88], … [89, 0)}.

## 3.6 Science Data Variables

These retrievals provide information on a wide variety of geophysical parameters, including temperature, water vapor, ozone, clouds, and surface parameters.

For each retrieved variable there is a corresponding variable in the /nobs group giving the number of observations associated with it. For example nobs/air_temp_nobs gives the number of observations contributing to each element of air_temp. In daily Level-3 products this counts the number of FOVs averaged, so the number of independent retrievals is lower. For monthly Level-3, nobs counts the number of days averaged.

Key science data fields are defined below. See the appendixes for a full listing.

**Table 3.6 Key Science Data Variables**

| Name | Dimensions | Description | Units |
|---|---|---|---|
| **air_temp** | orbit_pass, air_pres, lat, lon | air temperature profile | Kelvin |
| **surf_air_temp** | orbit_pass, lat, lon | near-surface air temperature (~2 meters above surface) | Kelvin |
| **surf_temp** | orbit_pass, lat, lon | radiative temperature of the surface | Kelvin |
| **h2o_vap_tot** | orbit_pass, lat, lon | total precipitable water vapor | kg / m2 |
| **spec_hum** | orbit_pass, air_pres_h2o, lat, lon | mass fraction of water vapor in moist air | unitless |
| **rel_hum** | orbit_pass, air_pres_h2o, lat, lon | relative humidity over equilibrium phase | unitless |
| **o3_tot** | orbit_pass, lat, lon | Total column ozone. (Multiply by 4.670e5 to convert to Dobson Units from kg m^-2) | kg m-2 |
| **cld_frac** | orbit_pass, lat, lon | effective cloud fraction | unitless |
| **lay_cld_frac** | orbit_pass, cld_pres_lay, lat, lon | coarse layer effective cloud fraction | unitless |
| **cld_top_pres** | orbit_pass, lat, lon | cloud top pressure | hPa |
| **tpause_pres** | orbit_pass, lat, lon | tropopause pressure, where tropopause is determined according to the WMO definition | Pa |

In addition to these, CHART has olr and olr_clr.

# 3.7 Quality Control

Quality Control (QC) for Level-3 is based on the QC information embedded in the Level-2 products. Level-3 values are means of accepted cases from Level-2. There are two QC strategies:

1) Specific QC (QCS) uses the QC values for each specific variable and level to determine which observations to include. This gives the greatest possible yield for any given level, but might give misleading results for lapse rates or other comparisons because different ensembles of observations are used for different levels and variables.
2) Comprehensive QC (QCC) uses only cases where the temperature and water vapor are QC 0 or 1 from the top of the atmosphere down to the surface. This gives a lower yield than QCS for most levels but can safely be used for lapse rates and other comparisons.

Because CLIMCAPS Level-2 QC already has a philosophy similar to QCC, only QCC L3 are produced for CLIMCAPS.

The CLIMCAPS and CHART Level-2 products include Quality Control (QC) scores of {0, 1, 2} for each level of each retrieved geophysical variable.

**Table: 3.7.1 Level-2 *_qc Values**

| Value | Meaning |
|---|---|
| **0** | Highest quality – use without reservation |
| **1** | Good quality – suitable for most purposes |
| **2** | Do not use. In some cases a physical value is present but is not considered reliable. In other cases only fill values are present. |

While the CHART and CLIMCAPS Level-2 products both have this structure, the philosophy of setting individual values is different. CLIMCAPS decides an entire FOR retrieval is good or bad and sets all levels of all variables collectively to 0 or 2. CHART makes different judgements per physical quantity and per pressure level, and uses the "1" intermediate quality level.

## 3.8 Missing Data / Fill Values

Fill values are used where there is no valid data, including profiles level with pressures greater than the surface pressure. The fill value is indicated by the attribute '_FillValue'. It is advised to check the data for fill values before it is used. The fill values per variable datatype are listed in the table below.

**Table: 3.8.1 Fill Values**

| Variable Type | Fill Value |
|---|---|
| **unsigned 8-bit integer** | 255UB |
| **unsigned 16-bit integer** | 65535US |
| **unsigned 32-bit integer** | 4294967295U |
| **floating point** | 9.96921e+36 |

## 3.9 Key supporting information variables for profiles

These variables provide supporting information to interpret the science variables.

| Name | Dimensions | Description | Units |
|---|---|---|---|
| **air_pres** | air_pres | pressure levels | Pa |
| **air_pres_h2o** | air_pres_h2o | H2O vapor pressure levels | Pa |
| **cld_pres_lay** | cld_pres_lay | pressure at the middle of each coarse cloud layer | Pa |
| **cld_pres_lay_bnds** | cld_pres_lay, bnds_1d | Min and max pressure of each cloud layer | Pa |
| **lat** | lat | Grid cell center latitudes (-89.5, -88.5, …89.5) | degrees_north |
| **lat_bnds** | lat, bnds_1d | Min and max latitude of each grid cell | degrees_north |

| | | | |
|---|---|---|---|
| **lon** | lon | Grid cell center longitudes (-179.5, -178.5, …179.5) | degrees_east |
| **lon_bnds** | lon, bnds_1d | Min and max longitude of each grid cell | degrees_east |
| **orbit_pass** | orbit_pass | nominal local solar time at equatorial overpass (13.5, 1.5) | hours |

## 3.10 Vertical profile representation of gases

Both retrievals maintain internal vertical profiles of gases on 100 fixed-pressure layers. This information is preserved in the Level-2 "mol_lay" subgroup. For the main public products in the <evel-3 product and the Level-2 root group, water vapor and ozone are reported on the 100 fixed-pressure levels which bound the layers. For water vapor, levels at pressures under 5153 Pa (51.53 hPa) are not reported.

Pressure levels below the surface are always filled with fill values.

Level concentrations of gases are estimated from the layer gas amounts using different approaches, based on different philosophies. For CHART, we use a smoothing spline fit to represent the limits of the vertical information that is present in the input CrIMSS data by removing sharper features which may be artifacts from SCCNN. For CLIMCAPS, a more direct interpolation preserves information from MERRA2 (see Section 3.11, GFS was accidentally used as the first guess) along with the information from the retrieval.

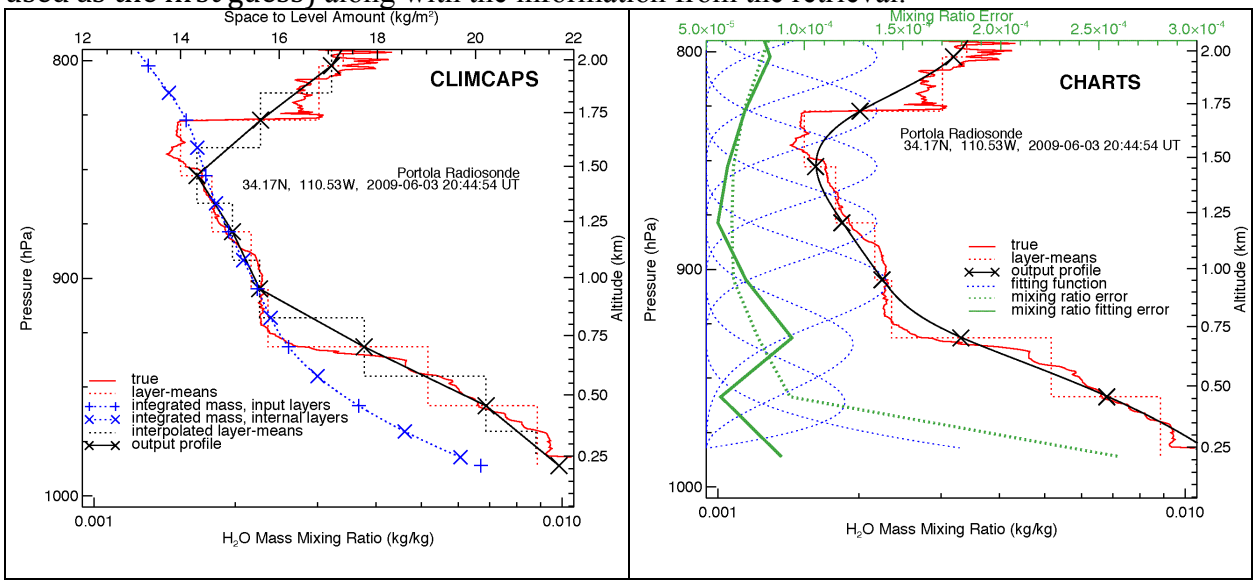



**Figure 1. Water vapor level concentration for CLIMCAPS and CHART.**

For CLIMCAPS, level concentrations of gases are estimated from layer-amounts using the mean-value theorem and assuming that layers with boundaries at

$$P_{\text{bnd}} = {}^{P_i - P_{i-1}}/_{\ln P_i - \ln P_{i-1}}$$

have mean values which estimate the profile at the levels $P_i$. Layer-mean mixing ratios are uniquely specified by the layer amounts, the temperature profile and pressure differences through the hydrostatic and hypsometric equations [Wallace and Hobbs, 1977, pgs. 53-54].

Figure 3a illustrates the procedure. A true radiosonde profile of water vapor mixing ratio is converted to layer amounts as would be produced by the CLIMCAPS algorithm. These are shown in the figure as mean mass mixing ratio, which is obtained by dividing the layer water vapor amount by the layer dry air amount. The amounts in each layer are summed from top to bottom to produce a piecewise linear profile of top-to-level integrated amount. The integrated amount is then interpolated to a new set of levels, $P_{bnd}$, and differenced to produce a new set of layer amount. Similarly, the dry-air top-to-level integrated amounts are interpolated to the new levels, and mean mixing ratios (ratio of gas amount to dry-air amount) are assumed to be the mixing ratio at the levels $P_i$. Values at the end points are linearly extrapolated from the profile at interior points. The reported profiles have errors from the interpolations and use of the mean value theorem[1]. The algorithm uses linear interpolation in log pressure and top-to-level amount which introduces larger errors when top-to-level amount second derivative is large; these errors are not included in mixing ratio error estimates.

Error estimates for the level mixing ratios are interpolated from the fractional layer-amount errors. Fractional error is assumed to be fully correlated and linearly interpolated in log pressure from the arithmetic mean pressures of each level (uncorrelated error involves linearly interpolating variance).

CHART level concentrations are estimated from the layer amounts by least squares fitting a profile to the CHART output layer amounts. The mixing ratio profile is represented as a sum of 4th-order bsplines:

$$X(P) = \sum_i A_i \, b_i(P),$$

the fitting solves for the coefficients $A_i$, subject to the layer column amounts, a climatological smoothness a priori, and constrained to match the column total. Figure 3b shows the same profile as in the previous figure, and shows the bspline functions, the fitted profile, and the error profile error estimates. This algorithm adds some smoothness to the output profile and performs comparable to the mean-value-theorem method, when the fitting functions are representative of the structure contained in the input layer quantities.

## 3.11 Known issues

The MERRA-2 first guess profile was accidentally overwritten by the GFS forecast file, so that in this 8-month sample run the apriori and all the "fg" variables are actually the GFS

[1] The mean value theorem says that some point in the interval has the mean value, but not where the point is located.

forecast interpolated to the time and location of the observation. For the purpose of evaluation of the behavior of CLIMCAPS versus CHART the use of GFS forecasts should not be significantly different than MERRA-2.

# 4.0 Options for Reading the Data

The product files are written in netCDF4/HDF5. Because netCDF4 builds upon the classic netCDF data model using HDF5 as the storage layer, a user of the data product can take full advantage of tools and libraries readily available to access the data.

Every netCDF4 file is considered an HDF5 file, however, not every HDF5 file is necessarily a netCDF4 file. A limited subset of the HDF5 data model and file format features are used in netCDF4 files. Conformance to the earlier mentioned CF & ACDD standards allows for users to take advantage of most netCDF interfaces.

Tools and libraries for reading netCDF4 as well as a netCDF Users' Guide are written and maintained by Unidata and can be found online at:
http://www.unidata.ucar.edu/software/netcdf/

Panoply is a good tool for visualizing these files. https://www.giss.nasa.gov/tools/panoply/

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

The files can also be accessed with HDF5 tools and libraries available at:
https://www.hdfgroup.org/products/hdf5_tools/

# 5.0 Data Services

The products are available to the user community via the Goddard Distributed Active Archive Center (GDAAC). https://disc.gsfc.nasa.gov/
Data at the GDAAC is organized by unique shortnames and version numbers.

| shortname.version | Description |
|---|---|
| ***CHART + CLIMCAPS Level-2 products described in this document*** | |
| SNDRSNIML3CDCCPN.1 | CLIMCAPS Level-3 Comprehensive QC 1-day retrieved product |
| SNDRSNIML3CMCCPN.1 | CLIMCAPS Level-3 Comprehensive QC monthly retrieved product |

| | |
|---|---|
| SNDRSNIML3CDCHTN.1 | CHART Level-3 Comprehensive QC 1-day retrieved product |
| SNDRSNIML3CMCHTN.1 | CHART Level-3 Comprehensive QC monthly retrieved product |
| SNDRSNIML3SDCHTN.1 | CHART Level-3 Specific QC 1-day retrieved product |
| SNDRSNIML3SMCHTN.1 | CHART Level-3 Specific QC monthly retrieved product |
| ***Related data sets at GDAAC*** | |
| SNDRSNIML2CCPRETN.1 | CLIMCAPS Level-2 retrieved product |
| SNDRSNIML2CHTRETN.1 | CHART Level-2 retrieved product |
| N/A | SNPP granule maps |
| SNPPCrISL1BNSR.1 | SNPP CrIS Level 1B Normal Spectral Resolution V1 used as input for the Level-2 retrievals |
| SNPPATMSL1B.1 | SNPP ATMS Level 1B Brightness Temperature V1 used as input for the Level-2 retrievals |

# Appendix A: Differences between CLIMCAPS and CHART Level-2 retrieval algorithms

Although CHART and CLIMCAPS share a common heritage, there are significant differences in implementation. They use different channels and vertical basis functions among other changes. Please see their respective ATBD documents for full details. Here are a few key differences.

### A.1 First guess

CLIMCAPS starts from a background geophysical state derived from MERRA2 (see Section 3.11, GFS was accidentally used as the first guess). CHART starts from the results of a neural net using CrIMSS data, and trained using ECMWF forecasts. This neural net is Stochastic Cloud Clearing Neural Net (SCCNN), and is provided by Adam Milstein of MIT.

### A.2 Iteration

CHART converges through several iterations of cloud clearing and refining geophysical state; CLIMCAPS does only a single cloud clearing.

### A.3 Error estimation approach

CLIMCAPS error estimates are produced as part of the SVD retrieval. CHART uses a regression trained on ECMWF data to predict likely errors.

### A.4 Quality Control approach

Both products include variables with names ending in "_qc" telling which values are safe to use (0: best quality; 1: good quality, 2: do not use) but the values are derived differently. CLIMCAPS declares each retrieval as successful or not based on whether all steps of the retrieval were able to execute successfully, so the values for almost all quantities and levels are identical. CHART uses thresholds based on the predicted error levels, applied individually to different retrieved parameters and atmospheric levels.

### A.5 Retrieved quantities

After the core retrieval of temperature, water vapor, clouds, and ozone, CHART and CLIMCAPS add different additional retrievals.

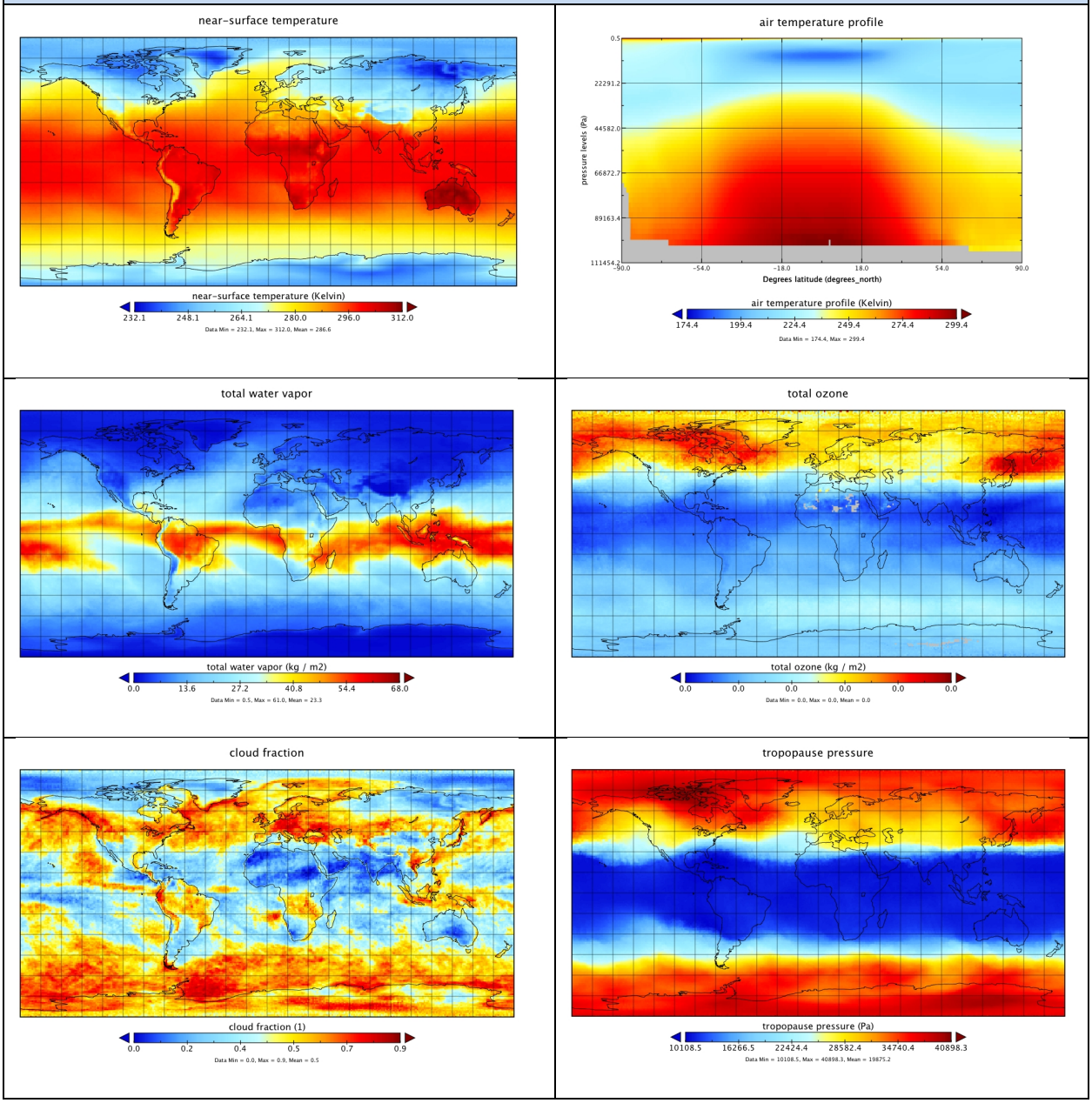
CHART has various Outgoing Longwave Radiation (OLR), independent per-FOV cloud pressure, and an infrared-based precipitation estimate.

CLIMCAPS retrieves these additional gases: $HNO_3$, $SO_2$, $N_2O$, and $CO_2$. For the v1 release, they are considered preliminary and not present in the level-3 product.

# Appendix B: Sample images

These images for January 2013 were generated with Panoply.

## 2013-01 CHART monthly Specific QC Ascending/day



# Appendix C: Detailed file formats

These tables show all of the dimensions, global attributes, and variables in the CrIMSS L3 product types.

For clarity, some variable attributes are omitted, including long_name, standard_name, coverage_content_type, axis, valid_range, coordinates, and _FillValue.

To get a complete listing including all variable attributes, apply "ncdump -h" to any netCDF4 product file.

The file formats for these six product types are almost identical. Highlighted sections show where there are differences:

- Where the name of the algorithm ("CHART" or "CLIMCAPS") appears, the generic format below instead has "<ALG>"
- Olr, olr_clr, olr_nobs, and olr_clr_nobs appear only in CHART products
- Duration fields differ for daily vs monthly products
- Shortnames differ per product as specified in section 5

## L3 CRIMSS Interface Specification

Interface Specification Version 02.00.28
04-10-2019

### Global Groups

| Path | Description |
|---|---|
| / | Science means |
| /nobs | Counts of observations |

### Global Dimensions

| Name | Size | Description |
|---|---|---|
| air_pres | 100 | Fine atmospheric pressure levels from top |
| air_pres_h2o | 66 | Fine atmospheric pressure levels for water vapor from top |
| orbit_pass | 2 | orbit pass: {Ascending/Day, Descending/Night} |
| lon | 360 | 1-degree longitude grid |
| lat | 180 | 1-degree latitude grid |
| cld_pres_lay | 3 | 3 coarse cloud layers: {high, mid, low} |
| bnds_1d | 2 | Boundaries for 1-d fields like lon: min, max |
| utc_tuple | 8 | parts of UTC time |

## Global Attributes

| Name | Type | Size | Value | Description |
|---|---|---|---|---|
| keywords | string | 1 | ATMOSPHERE > ATMOSPHERIC TEMPERATURE > UPPER AIR TEMPERATURE\, ATMOSPHERE > ATMOSPHERIC WATER VAPOR > WATER VAPOR | A comma-separated list of key words and/or phrases. Keywords may be common words or phrases, terms from a controlled vocabulary (GCMD is often used), or URIs for terms from a controlled vocabulary (see also "keywords_vocabulary" attribute). |
| Conventions | string | 1 | CF-1.6\, ACDD-1.3 | A comma-separated list of the conventions that are followed by the dataset |
| history | string | 1 | | Provides an audit trail for modifications to the original data. This attribute is also in the NetCDF Users Guide: 'This is a character array with a line for each invocation of a program that has modified the dataset. Well-behaved generic netCDF applications should append a line containing: date, time of day, user name, program name and command arguments.' To include a more complete description you can append a reference to an ISO Lineage entity; see NOAA EDM ISO Lineage guidance. |
| source | string | 1 | CrIS and ATMS 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'. |
| processing_level | string | 1 | 3 | A textual description of the processing (or quality control) level of the data. |
| product_name_type_id | string | 1 | L3_<ALG>_QCx_NSR | Product name as it appears in product_name (L1A, L1B, L2, SNO_AIRS_CrIS). x = C (Comprehesive) or S (Specific) |
| comment | string | 1 | | Miscellaneous information about the data or methods used to produce it. Can be empty. |
| acknowledgment | string | 1 | Support for this research was provided by NASA. | A place to acknowledge various types of support for the project that produced this data. |
| license | string | 1 | 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. |
| standard_name_vocabulary | string | 1 | 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'. |
| date_created | string | 1 | Unassigned | The date on which this version of the data was created. (Modification of values implies a new version, hence this would be assigned the date of the most recent values modification.) Metadata changes are not considered when assigning the date_created. The ISO 8601:2004 extended date format is recommended, as described in the Attribute Content Guidance section. |
| creator_name | string | 1 | Unassigned | The name of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data. |

| Name | Type | Size | Value | Description |
|---|---|---|---|---|
| creator_email | string | 1 | Unassigned | The email address of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data. |
| creator_url | string | 1 | Unassigned | The URL of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data. |
| institution | string | 1 | Unassigned | Processing facility that produced this file |
| project | string | 1 | 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'. |
| product_name_project | string | 1 | SNDR | The name of the project as it appears in the file name. 'SNDR' for all Sounder SIPS products, even AIRS products. |
| publisher_name | string | 1 | 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. |
| publisher_email | string | 1 | 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. |
| publisher_url | string | 1 | 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. |
| geospatial_bounds | string | 1 | POLYGON ((-90.0 -180.0\, 90.0 -180.0\, 90.0 180.0\, -90.0 180.0\, -90.0 -180.0)) | Describes the data's 2D or 3D geospatial extent in OGC's Well-Known Text (WKT) Geometry format (reference the OGC Simple Feature Access (SFA) specification). The meaning and order of values for each point's coordinates depends on the coordinate reference system (CRS). The ACDD default is 2D geometry in the EPSG:4326 coordinate reference system. The default may be overridden with geospatial_bounds_crs and geospatial_bounds_vertical_crs (see those attributes). EPSG:4326 coordinate values are latitude (decimal degrees_north) and longitude (decimal degrees_east), in that order. Longitude values in the default case are limited to the -180, 180) range. Example: 'POLYGON ((40.26 -111.29, 41.26 -111.29, 41.26 -110.29, 40.26 -110.29, 40.26 -111.29))'. |
| geospatial_bounds_crs | string | 1 | 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'. |
| geospatial_lat_min | float | 1 | | Describes a simple lower latitude limit; may be part of a 2- or 3-dimensional bounding region. |

| Name | Type | Size | Value | Description |
|---|---|---|---|---|
| | | | | Geospatial_lat_min specifies the southernmost latitude covered by the dataset. |
| geospatial_lat_max | float | 1 | | Describes a simple upper latitude limit; may be part of a 2- or 3-dimensional bounding region. Geospatial_lat_max specifies the northernmost latitude covered by the dataset. |
| geospatial_lon_min | float | 1 | | Describes a simple longitude limit; may be part of a 2- or 3-dimensional bounding region. geospatial_lon_min specifies the westernmost longitude covered by the dataset. See also geospatial_lon_max. |
| geospatial_lon_max | float | 1 | | 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). |
| time_coverage_start | string | 1 | | Nominal start time. Describes the time of the first data point in the data set. Use the ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section. |
| time_of_first_valid_obs | string | 1 | | Describes the time of the first valid data point in the data set. Use the ISO 8601:2004 date extended format. |
| time_coverage_mid | string | 1 | | Describes the midpoint between the nominal start and end times. Use the ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section. |
| time_coverage_end | string | 1 | | Nominal end time. Describes the time of the last data point in the data set. Use ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section. |
| time_of_last_valid_obs | string | 1 | | Describes the time of the last valid data point in the data set. Use the ISO 8601:2004 date extended format. |
| time_coverage_duration | string | 1 | P0000-00-01T00:00:00/ P0000-00-00T00:00:00 | Describes the duration of the data set. Use ISO 8601:2004 duration format, preferably the extended format as recommended in the Attribute Content Guidance section. |
| product_name_duration | string | 1 | D01 / M01 | Product duration as it appears in product_name (D01 means full day) |
| creator_type | string | 1 | 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. |
| creator_institution | string | 1 | 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. |

| Name | Type | Size | Value | Description |
|---|---|---|---|---|
| product_version | string | 1 | | Version identifier of the data file or product as assigned by the data creator. For example, a new algorithm or methodology could result in a new product_version. |
| keywords_vocabulary | string | 1 | 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'. |
| platform | string | 1 | SUOMI-NPP > Suomi National Polar-orbiting Partnership | Name of the platform(s) that supported the sensor data used to create this data set or product. Platforms can be of any type, including satellite, ship, station, aircraft or other. Indicate controlled vocabulary used in platform_vocabulary. |
| platform_vocabulary | string | 1 | GCMD:GCMD Keywords | Controlled vocabulary for the names used in the "platform" attribute. |
| product_name_platform | string | 1 | SNPP | Platform name as it appears in product_name |
| instrument | string | 1 | CRIMSS > Cross-track Infrared and Advanced Technology Microwave Sounders\, CrIS > Cross-track Infrared Sounder\, ATMS > Advanced Technology Microwave 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. |
| instrument_vocabulary | string | 1 | GCMD:GCMD Keywords | Controlled vocabulary for the names used in the "instrument" attribute. |
| product_name_instr | string | 1 | CRIMSS | Instrument name as it appears in product_name |
| product_name | string | 1 | | Canonical fully qualified product name (official file name) |
| product_name_variant | string | 1 | std | Processing variant identifier as it appears in product_name. 'std' (shorthand for 'standard') is to be the default and should be what is seen in all public products. |
| product_name_version | string | 1 | vxx_xx_xx | Version number as it appears in product_name (v01_00_00) |
| product_name_producer | string | 1 | T | Production facility as it appears in product_name (single character) 'T' is the default, for unofficial local test products |
| product_name_timestamp | string | 1 | yymmddhhmmss | Processing timestamp as it appears in product_name (yymmddhhmmss) |
| product_name_extension | string | 1 | nc | File extension as it appears in product_name (typically nc) |
| gran_id | string | 1 | yyyymmdd | Unique granule identifier yyyymmdd of granule start day, including year, month, and day of granule start time |
| featureType | string | 1 | point | structure of data in file |

| Name | Type | Size | Value | Description |
|---|---|---|---|---|
| data_structure | string | 1 | grid | a character string indicating the internal organization of the data with currently allowed values of 'grid', 'station', 'trajectory', or 'swath'. The 'structure' here generally describes the horizontal structure and in all cases data may also be functions, for example, of a vertical coordinate and/or time. (If using CMOR pass this in a call to cmor_set_cur_dataset_attribute.) |
| cdm_data_type | string | 1 | Grid | The data type, as derived from Unidata's Common Data Model Scientific Data types and understood by THREDDS. (This is a THREDDS "dataType", and is different from the CF NetCDF attribute 'featureType', which indicates a Discrete Sampling Geometry file in CF.) |
| id | string | 1 | Unassigned | An identifier for the data set, provided by and unique within its naming authority. The combination of the "naming authority" and the "id" should be globally unique, but the id can be globally unique by itself also. IDs can be URLs, URNs, DOIs, meaningful text strings, a local key, or any other unique string of characters. The id should not include white space characters. |
| naming_authority | string | 1 | Unassigned | The organization that provides the initial id (see above) for the dataset. The naming authority should be uniquely specified by this attribute. We recommend using reverse-DNS naming for the naming authority; URIs are also acceptable. Example: 'edu.ucar.unidata'. |
| identifier_product_doi | string | 1 | Unassigned | digital signature |
| identifier_product_doi_authority | string | 1 | Unassigned | digital signature source |
| algorithm_version | string | 1 | | 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. |
| production_host | string | 1 | | Identifying information about the host computer for this run. (Output of linux "uname -a" command.) |
| format_version | string | 1 | v02.00.28 | Format version. |
| input_file_names | string | 1 | | Semicolon-separated list of names or unique identifiers of files that were used to make this product. There will always be one space after each semicolon. There is no final semicolon. |
| input_file_types | string | 1 | | 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. |
| input_file_dates | string | 1 | | 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. |
| AutomaticQualityFlag | string | 1 | Missing | "Passed": the granule contains a non-degraded calibrated brightness temperature, radiance, or retrieved value for at least one value in a geolocated FOV; "Suspect": the granule does not qualify as "Passed" but contains a (possibly degraded) calibrated or retrieved value (possibly without associated |

| Name | Type | Size | Value | Description |
|---|---|---|---|---|
| | | | | geolocation); "Failed": the granule contains no calibrated or retrieved values. |
| qa_no_data | string | 1 | TRUE | A simple indicator of whether this is an "empty" granule with no data from the instrument. "TRUE" or "FALSE". |
| title | string | 1 | Level-3 <ALG> SNPP CrIMSS | a succinct description of what is in the dataset. (= ECS long name) |
| summary | string | 1 | The Level-3 <ALG> daily product includes atmospheric state retrieval products from the <ALG> algorithm for one day. These include temperature and water vapor profiles as well as cloud and surface products and minor gases. | A paragraph describing the dataset, analogous to an abstract for a paper. |
| shortname | string | 1 | | ECS Short Name |
| metadata_link | string | 1 | Unassigned | A URL that gives the location of more complete metadata. A persistent URL is recommended for this attribute. |
| references | string | 1 | | ATDB and design documents describing processing algorithms. Can be empty. |

## Global Variables

| Name | Type | Dimensions | Description | Units |
|---|---|---|---|---|
| air_pres | float32 | air_pres | pressure levels | Pa |
| air_pres_h2o | float32 | air_pres_h2o | H2O vapor pressure levels | Pa |
| air_temp | float32 | orbit_pass, air_pres, lat, lon | air temperature profile on 100 levels | Kelvin |
| surf_air_temp | float32 | orbit_pass, lat, lon | near-surface air temperature (~2 meters above surface) | Kelvin |
| surf_temp | float32 | orbit_pass, lat, lon | radiative temperature of the surface | Kelvin |
| h2o_vap_tot | float32 | orbit_pass, lat, lon | total precipitable water vapor | kg / m2 |
| spec_hum | float32 | orbit_pass, air_pres_h2o, lat, lon | mass fraction of water vapor in moist air | unitless |
| rel_hum | float32 | orbit_pass, air_pres_h2o, lat, lon | relative humidity over equilibrium phase | unitless |
| o3_tot | float32 | orbit_pass, lat, lon | Total column ozone. (Multiply by 4.670e5 to convert to Dobson Units from kg m^-2) | kg / m2 |
| cld_frac | float32 | orbit_pass, lat, lon | effective cloud fraction | unitless |

| Name | Type | Dimensions | Description | Units |
|---|---|---|---|---|
| lay_cld_frac | float32 | orbit_pass, cld_pres_lay, lat, lon | coarse layer effective cloud fraction | unitless |
| cld_top_pres | float32 | orbit_pass, lat, lon | cloud top pressure | Pa |
| tpause_pres | float32 | orbit_pass, lat, lon | tropopause pressure, where tropopause is determined according to the WMO definition | Pa |
| olr | float32 | orbit_pass, lat, lon | outgoing longwave radiation flux integrated over 2 to 2800 cm-1 | W / m2 |
| olr_clr | float32 | orbit_pass, lat, lon | clear-sky outgoing longwave radiation flux integrated over 2 to 2800 cm-1 | W / m2 |
| surf_alt | float32 | orbit_pass, lat, lon | mean surface altitude wrt earth model for observations | m |
| prior_surf_pres | float32 | orbit_pass, lat, lon | surface pressure from forecast for observations | Pa |
| obs_time_tai93 | double | orbit_pass | Nominal midtime for observations included in grid | seconds since 1993-01-01 00:00 |
| obs_time_utc | uint16 | orbit_pass, utc_tuple | Nominal midtime for observations included in grid as an array of integers: year, month, day, hour, minute, second, millisec, microsec | |
| lon | float32 | lon | Degrees longitude | degrees_east |
| lat | float32 | lat | Degrees latitude | degrees_north |
| cld_pres_lay | float32 | cld_pres_lay | coarse cloud pressure layers | Pa |
| cld_pres_lay_lbl | string | cld_pres_lay | Altitude labels for cloud pressure layers | |
| orbit_pass | float32 | orbit_pass | Nominal solar time when the spacecraft passes over the equator. Orbit pass bounds are defined by closest approach of the spacecraft to the poles. | hours |
| 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 | |

nobs Variables

| Name | Type | Dimensions | Description | Units |
|---|---|---|---|---|
| air_temp_nobs | int32 | orbit_pass, air_pres, lat, lon | air_temp number of observations | unitless |
| surf_air_temp_nobs | int32 | orbit_pass, lat, lon | surf_air_temp number of observations | unitless |
| surf_temp_nobs | int32 | orbit_pass, lat, lon | surf_temp number of observations | unitless |
| h2o_vap_tot_nobs | int32 | orbit_pass, lat, lon | h2o_vap_tot number of observations | unitless |
| spec_hum_nobs | int32 | orbit_pass, air_pres_h2o, lat, lon | spec_hum number of observations | unitless |
| rel_hum_nobs | int32 | orbit_pass, air_pres_h2o, lat, lon | rel_hum number of observations | unitless |
| o3_tot_nobs | int32 | orbit_pass, lat, lon | o3_tot number of observations | unitless |

| Name | Type | Dimensions | Description | Units |
|---|---|---|---|---|
| cld_frac_nobs | int32 | orbit_pass, lat, lon | cld_frac number of observations | unitless |
| cld_top_pres_nobs | int32 | orbit_pass, lat, lon | cld_top_pres number of observations | unitless |
| tpause_pres_nobs | int32 | orbit_pass, lat, lon | tpause_pres number of observations | unitless |
| olr_nobs | int32 | orbit_pass, lat, lon | olr number of observations | unitless |
| olr_clr_nobs | int32 | orbit_pass, lat, lon | olr_clr number of observations | unitless |
| surf_alt_nobs | int32 | orbit_pass, lat, lon | surf_alt number of observations | unitless |
| prior_surf_pres_nobs | int32 | orbit_pass, lat, lon | prior_surf_pres number of observations | unitless |
| nobs_max | int32 | orbit_pass, lat, lon | Maximum number of observations including those for which no value was retrieved | unitless |