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

# README Document for Suomi-NPP OMPS NMCLDRR-L2 Product

Version 2.0

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Goddard Earth Sciences Data and Information Services Center (GES DISC)
https://disc.gsfc.nasa.gov
NASA Goddard Space Flight Center
Code 610.2
Greenbelt, MD 20771 USA

**Prepared By:**


*James Johnson*

Name
GES DISC
GSFC Code 610.2

3/2/2020

Date

*Alexander Vasilkov and Joanna Joiner*

Name
SSAI/NASA GSFC Code 614


**Reviewed By:**

Reviewer Name

Reviewer Name
GES DISC
GSFC Code 613.2

Date

Date

**Goddard Space Flight Center**
**Greenbelt, Maryland**

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| | | |

# Table of Contents

# 1.0 Introduction

This document provides basic information for using the Suomi National Polar-orbiting Partnership (NPP) Ozone Mapping and Profiling Suite (OMPS) Nadir Mapper (NM) Cloud Level2 product, or OMPS-NPP_NMCLDRR-L2 for short. OMPS-NPP_NMCLDRR-L2 provides effective cloud fraction (ECF) and effective cloud pressure, a. k. a. optical centroid pressure (OCP) retrievals determined from normalized radiance measurements taken by the NM sensor. The current version of this product provides cloud radiance fraction (CRF) retrievals as well. Each file contains one orbit's worth of data.

## 1.1 OMPS Instrument Description

The Ozone Mapping and Profiling Suite (OMPS) is designed to measure the global distribution of total column ozone on a daily basis, as well as the vertical distribution of ozone in the stratosphere and lower mesosphere (~15-60 km). OMPS on the Suomi NPP satellite consists of three instruments:

Nadir Mapper (NM) – The Nadir Mapper measures total column ozone using backscattered UV radiation between 300-380 nm. A wide field-of-view telescope enables full daily global coverage using 50 km x 50 km pixels. Other quantities, such as aerosol index and column $SO_2$ abundance, can be derived from NM measurements.

Nadir Profiler (NP) – The Nadir Profiler measures stratospheric profile ozone with moderate vertical resolution (6-8 km) using backscattered UV radiation between 250-310 nm. The along-track footprint of NP is 250 km x 250 km.

Limb Profiler (LP) – The Limb Profiler measures limb scattered radiation in the UV, visible, and near-IR spectral regions to retrieve ozone density and aerosol extinction coefficient profiles from the lower stratosphere (10-15 km) to the upper stratosphere (55 km).

Only products derived from OMPS NM measurements will be described here.

### 1.1.1 Nadir Mapper

The OMPS nadir instrument is composed of two spectrometers that share the same telescope. A dichroic filter downstream of the telescope redirects photons into either the NM or the Nadir Profiler (NP) spectrometer. The telescope itself has a 110° total across-track field of view (FOV), resulting in 2800 km instantaneous coverage at the Earth's surface; this is sufficient to provide daily full global coverage at the equator for the NM sensor. The telescope includes a pseudo depolarizer (*McClain et al.*, 1992) designed to minimize the system's sensitivity to incoming polarization. The dichroic filter is optimized to reflect most of the 250–310 nm light to the NP spectrometer and transmit most of the 300–380 nm light to the NM spectrometer.

Once split, the light from the NM spectrometer is dispersed via a diffraction grating onto one dimension of a two dimensional charge-coupled device (CCD) located at the spectrometer's focal plane. The second dimension reflects the cross-track spatial coverage provided by the slit aperture and optics. The CCD consists of 340 pixels along the spectral dimension and 740 pixels in the across-track spatial dimension.

Measurements meeting the 300–380 nm wavelength range specification required by the NM sensor are obtained by illuminating 196 of the 340 pixels in the spectral dimension. In the across-track dimension, 708 pixels are illuminated. For nominal operations, the pixel signals are summed into 35 separate "macropixel" FOVs; all but the two outer FOVs contain 20 pixels per macropixel; the left outermost macropixel contains 26 pixels, while the right outermost contains 22. Since the readout of the CCD is split in the center, measurements comprising the central FOV are actually split (although not symmetrically). Rather than rebinning these measurements in ground processing, they remain split, resulting in 36 cross-track FOVs. In this case, the central two FOVs comprise 12 pixels (30× 50km) and 8 pixels (20 × 50 km), respectively.

Because macropixels are constructed in programmable flight electronics, the OMPS nadir temporal (along-track) and spatial (across-track) resolutions are highly configurable. High-resolution measurements, approximately 10 km× 10 km at nadir, have been routinely collected 1 day per week for the first 2 years of the mission. To remain within the telemetry bandwidth constraints, a set of only 59 wavelengths was selected; this selection still allows retrievals of total column ozone and other quantities (such as $SO_2$).

## 1.2 Algorithm Background

The OMI cloud pressure product is necessary for correction of the mission-critical total ozone product. Cloud pressure is derived from the high frequency structure in the top-of-atmosphere reflectance in the UV caused by rotational Raman scattering (RRS) in the atmosphere. RRS (also known as the Ring effect) results in filling-in of Fraunhofer lines in the backscatter UV spectra. Clouds reduce the amount of filling-in of Fraunhofer lines, with the amount of filling-in related to the cloud pressure. The cloud pressure algorithm retrieves the effective cloud pressure, a.k.a. optical centroid pressure (OCP) and effective cloud fraction (ECF) using a concept of the Mixed Lambert Equivalent Reflectivity (MLER). The MLER model treats cloud and ground as horizontally homogeneous Lambertian surfaces and mixes them using the independent pixel approximation (*Stammes et al.*, 2008). The ECF is retrieved at 354.1 nm, a wavelength free from

RRS. Cloud OCPs are the appropriate quantity for use in trace-gas retrievals from satellite instruments (*Vasilkov et al.*, 2008; *Ziemke et al*., 2009). Cloud top pressures derived from thermal IR measurements are not equivalent to OCPs and do not provide good estimates of solar photon pathlengths through clouds that are needed for trace-gas retrievals from UV/Vis backscatter measurements. The ECF is used to estimate the cloud radiance fraction (CRF) at 354.1 nm. This quantity is defined at each pixel as the fraction of the measured radiance that is scattered by clouds, *i.e*., the effective cloud fraction times the assumed cloudy radiance divided by the measured radiance. Because the measured radiance is wavelength dependent due to surface albedo and Rayleigh scattering, the cloud radiance fraction is also wavelength dependent. The CRF and OCP products are inputs for other OMPS trace gas retrievals including formaldehyde (*Abad et al*., 2016).

The original (prelaunch) estimates of the accuracy and precision of the effective cloud pressure retrieval were 100 and 30 hPa, respectively. Comparisons with MODIS (*Joiner and Vasilkov*, 2006; *Joiner et al.*, 2010) and CloudSat (*Vasilkov et al*., 2008) are consistent with radiative transfer calculations that show enhancement in scattering from multi-layer clouds (they occur frequently) and significant light penetration into physically thick clouds, especially deep convective clouds (*Ziemke et al*., 2009). Based on these comparisons and considerations, we believe that our original error estimates are reasonable for optically thick clouds ($\tau > 20$) and for lower $\tau$ at solar zenith angles (SZA) near 45$^{o}$. However, at lower $\tau$ and higher and lower SZA, the retrieved cloud pressures may have significant errors, though they should still be sufficiently accurate for use in trace gas retrievals.

For a detailed description of the algorithm used in NMCLDRR-L2 please refer to *Vasilkov et al*. (2014). The NMCLDRR-L2 algorithm is a heritage product from the OMI cloud algorithm, OMCLDRR. There are several journal papers related to the OMCLDRR. These include *Joiner et al*. (2004), *Vasilkov et al.* (2004), *Joiner and Vasilkov* (2006), and *Vasilkov et al.* (2008). *Joiner and Vasilkov* (2006) contains a description of a soft-calibration procedure that is used to remove scan position-dependent biases (*i.e.* striping) from the retrieved OCPs. *Vasilkov et al.* (2008) and *Joiner et al.* (2011) contain detailed error analyses and validation using CloudSat/MODIS 2B-TAU optical extinction profiles.

Algorithm Features:

1) We use the fitting window 346-354 nm. There is significantly more Rayleigh scattering at these wavelengths that mitigates (but does not completely eliminate) problems associated with contribution of Raman scattering in the ocean and non-Lambertian behavior of the ground.

2) Under low cloud fraction conditions (ECF<~0.3), sea glint can produce high values of retrieved reflectivity and low values of cloud pressure. Sea glint primarily affects the West side of swath at low and mid-latitudes. To mitigate the sun glint problem we introduced the Cox-Munk Lambertian-equivalent reflectivity (LER) over the oceans. This effectively accounts for specular reflection of solar light from the rough ocean surface. The correction was derived from radiative transfer simulations in a Rayleigh atmosphere with the rough ocean surface with slopes described by the Cox-Munk slope distribution function. The Cox-Munk LER correction is applied on the top of an adjusted surface reflectivity climatology from TOMS measurements. The adjusted surface reflectivity climatology effectively accounts for diffuse water-leaving reflectance. The Cox-Munk LER correction improves cloud fraction and cloud pressure retrievals (cross track dependence) mostly over sun glint areas.
3) Over snow/ice, the processing quality flag bit 5 is set to 1, and the cloud fraction is assigned to 1. Therefore, the effective cloud pressure for these pixels is represents an average scene pressure (*i.e*. the LER pressure of a pixel that produces the observed amount of Raman scattering). This is done in order to more positively identify the existence of thick clouds over snow/ice (see *Vasilkov et al*. (2010) for a detailed discussion). This is of interest for the retrieval of ozone and other trace gases as well as the calculation of surface UVB. The snow/ice information comes from the Near real-time Ice and Snow Extent (NISE) product created using passive microwave data. It is provided by the National Snow and Ice Data Center (NSIDC) and is included in the level 1b data set.
4) As the cloud radiance fraction tends to zero, the error in retrieved cloud pressure increases rapidly. These errors can be seen in some cases where cloud fractions are very low (20% or less). For effective cloud fractions < 5%, we do not attempt a cloud pressure retrieval. Instead, an effective scene pressure is reported for diagnostic purposes only. These cases are indicated where bit 13 of the processing quality flag is set to 1. Retrievals for effective cloud fractions < 20% should be used with caution.
5) Absorbing aerosol in and above clouds can affect the NMCLDRR-L2 data. In general, it will reduce cloud fractions and pressures. The presence of absorbing aerosols is currently not flagged in the NMCLDRR-L2 file. The aerosol index flag in the NMTO3-L2 file can be used to check for the existence of absorbing aerosol within a pixel.
6) Cloud fractions and subsequently the cloud pressures are sensitive to the instrument calibration and any calibration drift. Until the instrument calibration has been fully characterized as a function of time, users are cautioned not to use these products for deriving long-term trends.
7) An essential element of NMCLDRR-L2 is a soft-calibration that reduces striping in the retrieved OCP. The soft-calibration is performed over the Antarctic plateau. However,

the soft-calibration is designed to remove multiplicative errors. Our soft calibration will not be able to fully remove additive errors. We have not made any adjustments to account for possible trends in absolute calibration that may affect both the effective cloud fraction and pressure.

8) Version 2.0 adds a post processing step onto the previous version that provides a bias adjustment to correct for a known cross-track bias (presumably caused by stray light) that affects mainly partly cloudy scenes. The adjustment is a function of cross track position and depends upon the clear-sky radiance and the cloud fraction.
9) Cross track positions 35 and particularly 36 have shown anomalously cloud pressures. Efforts are ongoing to identify the cause of these poor quality data and to automatically detect and flag them.

Data Disclaimer

Special high resolution diagnostic data were taken every Sunday from the beginning of the mission until 4 August 2013. Between 4 August 2013 and 25 June 2016, these data were taken every Saturday. Data for these days are not included as part of this product.

## 1.3 What's New?

The initial version of the NMCLDRR data product, designated V1.0, was created for internal review. After validation, it was determined that some revisions were needed before final release. The current NMCLDRR-L2 product is designated V2.0 and includes both science and non-science changes from the previous version.

*Science-related changes*

1) V2.0 adds a post processing step onto the previous version that provides a bias adjustment to correct for a known cross-track bias (presumably caused by stray light) that affects mainly partly cloudy scenes.
2) The V2.0 product uses V2.0 of NMEV-L1B as input. The V2.0 L1B provides improved radiance calibration.
3) GroundPixelQualityFlags and InstrumentQualityFlags have been added to the GeolocationGroup

*Non-science related changes*

4) The naming convention for the L1B input dataset has been changed from TC_SDR_EV_NASA to NMEV-L1B:
   a. TC (Total Column) has been replaced by NM (Nadir Mapper).

   b. NOAA nomenclature (SDR) has been replaced by NASA nomenclature (L1B).

5) All capitalization of names within the file has been replaced by capitalization of selected letters for easier interpretation.
6) Underlines in all names have been eliminated.

# 2.0 Data Organization

The output file contains swath-based radiance data for the daylit part of one orbit. There are typically 36 cross-track measurements per swath and 400 swath-based observations per orbit.

## 2.1 File Naming Convention

The OMPS Nadir Mapper data products use the following file name convention:

**OMPS**-satellite_sensorproduct-**L**level_**v**m.n_observationDate_productionTime.**h5**

Where:

- satellite = NPP
- sensorproduct = NMCLDRR
- level = 2
- m.n = algorithm version identifier (m = major, n = minor)
- observationDate = start date of measurements in *yyyymmdd* format
  - *yyyy* = 4-digit year number[2012-current]
  - *mm* = 2-digit month number [01-12]
  - *dd* = 2-digit day number [01-31]
- productionTime = file creation stamp in *yyyy***m***mmdd***t***hhmmss* format
  - *hhmmss* = production time [local time]

Filename example:

OMPS-NPP_NMCLDRR-L2_v2.0_ 2019m0606t000523_o39408_2020m0227t015757.h5

## 2.2 File Format and Structure

NMCLDRR-L2 data files are provided in the HDF5 format (Hierarchical Data Format Version 5), developed at the National Center for Supercomputing Applications https://www.hdfgroup.org/. These files use the Swath data structure format.

The top-most level in the HDF5 hierarchy of NMCLDRR-L2 files contains five different groups. Two of these groups (AncillaryData and CalibrationData) are currently empty. The InputPointers group contains high level information on input data. Two other groups contain pixel-dependent data: GeolocationData (containing data to geolocate each pixel, as well as spacecraft location and pointing information), and ScienceData (containing the output data, quality flags, and error terms). These groups are described in more detail in Section 3.

## 2.3 Key Science Data Fields

The data fields most likely to be used by typical users of the NMCLDRR-L2 product are listed in this section.

| Parameter | Group |
|---|---|
| Latitude | GeolocationFields |
| Longitude | GeolocationFields |
| CloudFractionforO3 | ScienceData |
| CloudPressureforO3 | ScienceData |
| RadiativeCloudFraction | ScienceData |
| Reflectivity | ScienceData |

### 2.3.1 Data Temporal Coverage

The first OMPS NMEV measurements used to create the NMEV-L1B product that is subsequently used to create the NMCLDRR-L2 product were taken on January 28, 2012. Data for February-March 2012 have numerous gaps due to variations in instrument operations. Regular operations began on April 2, 2012. Note that the OMPS Nadir Mapper conducted high-resolution measurements approximately one day per week from April 2012 to June 2016.

# 3.0 Data Contents

## 3.1 Dimensions

NMCLDRR-L2 includes the following dimension terms:

| Name | long_name | Size |
|---|---|---|
| DimAlongTrack | Along-track dimension | 400 |
| DimCrossTrack | Cross-track dimension | 36 |
| DimWavelength | Spectral dimension | 12 |
| DimCorners | FOV corners dimension | 4 |
| DimPressureLevel | Vertical Pressure Dimension | 11 |

## 3.2 Global Attributes

Metadata in NMCLDRR-L2 data files includes attributes whose value is constant for all files and attributes whose value is unique to each individual file. Table 3.2.1 summarizes these global attributes.

| Global Attribute | Type | Description |
|---|---|---|
| APPName | String | Software name |
| APPVersion | String | Software version |
| ArchiveSetName | String | Archive set name for processing |
| ArchiveSetNumber | Integer*8 | Archive set number for processing |
| Conventions | String | Name of convention(s) for metadata |
| DATA_QUALITY | Integer | Quality of the data |
| DOI | String | DOI value |
| DayNightFlag | String | Identify day or night measurements |
| EquatorCrossingDate | String | Date of equator crossing |
| EquatorCrossingLongitude | Real*4 | Longitude of equator crossing |
| EquatorCrossingTime | String | Time of equator crossing |
| Format | String | Data file format |
| LocalGranuleID | String | File name |
| LongName | String | Full product name |
| OrbitNumber | Integer*8 | First orbit number of day |
| PGEVersion | String | Software version (same as APPVersion) |
| ProductionDateTime | String | Time of file creation |
| RangeBeginningDateTime | String | Starting date and time of data |
| RangeEndingDateTime | String | Ending date and time of data |
| SAMP_TBL | Integer | Number of sample table used to take data |
| SAMP_TBL_VER | Integer | Version of the sample table used to take data |
| ShortName | String | Short product name |
| VersionID | Integer*4 | Version ID for this product |
| VersionNumber | String | Version number for this product |
| acknowledgement | String | Acknowledgement of data producer |

| | | |
|---|---|---|
| comment | String | Any additional comments |
| contributor_name | String | Name of data creator |
| contributor_role | String | Role of data creator |
| creator_email | String | e-mail address of data creator |
| creator_institution | String | Organization of data creator |
| creator_name | String | Name of data creator |
| creator_type | String | Type of data creator (e.g. person, organization) |
| date_created | String | Date of file creation |
| geospatial_bounds | String | Geographical boundaries of the granule |
| history | String | History of file |
| id | String | Short product name |
| institution | String | Producer of data |
| instrument | String | Instrument making measurements |
| instrument_vocabulary | String | Source of instrument terms |
| keywords | String | Identifying keywords |
| keywords_vocabulary | String | Source of keywords used in metadata |
| license | String | Source of data information regulations |
| metadata link | String | Web address for metadata DOI |
| naming_authority | String | Organization providing naming information |
| platform | String | Platform for measuring instrument |
| platform_vocabulary | String | Source of platform terms |
| processing_level | String | Level of data product (e.g. L1B, L2) |
| program | String | Type of measurement program |
| project | String | Name of project |
| publisher_email | String | e-mail address of data publisher |
| publisher_institution | String | Organization of data publisher |
| publisher_name | String | Name of data publisher |
| publisher_type | String | Organization type of data publisher |
| publisher_url | String | URL of data publisher |
| references | String | Reference material for data product |
| source | String | Source of measurement data |
| summary | String | Any additional summary |
| time_coverage_end | String | Ending data and time of data |
| time_coverage_start | String | Starting date and time of data |
| title | String | Title of data product |

## 3.3 Products/Parameters

### 3.3.1 GeolocationData Group

| Dataset Name | Description | Dimensions | Units |
|---|---|---|---|
| GroundPixelQualityFlags | Ground pixel quality flag (bit packed) | DimAlongTrack, DimCrossTrack | (no units) |
| Latitude | Ground pixel latitude | DimAlongTrack, DimCrossTrack | degrees_North |
| LatitudeCorner | Latitude values for ground pixel corners (CCW relative to flight direction: lower left, lower right, upper right, upper left) | DimAlongTrack, DimCrossTrack, DimCorners | degrees_North |

| | | | |
|---|---|---|---|
| Longitude | Ground pixel longitude | DimAlongTrack, DimCrossTrack | degrees_East |
| LongitudeCorner | Longitude values for ground pixel corners (CCW relative to flight direction: lower left, lower right, upper right, upper left) | DimAlongTrack, DimCrossTrack, DimCorners | degrees_East |
| RelativeAzimuthAngle | Difference between viewing and solar azimuth angles | DimAlongTrack, DimCrossTrack | degrees |
| SolarAzimuthAngle | Solar azimuth of each pixel | DimAlongTrack, DimCrossTrack | degrees |
| SolarZenithAngle | Solar zenith angle of each pixel | DimAlongTrack, DimCrossTrack | degrees |
| TerrainHeight | Empty currently | | |
| ViewingZenithAngle | Satellite zenith angle of each pixel | DimAlongTrack, DimCrossTrack | degrees |

Definition of bit-packed GroundPixelQualityFlags

| | | | |
|---|---|---|---|
| 0-3 | Unused | | |
| 4-5 | SAA Flag | WARNING | Indicates location of spacecraft w.ith respect to South Atlantic Anomaly (SAA)<br>0 = outside SAA boundaries<br>1 = <5% of nominal maximum SAA effect<br>2 = between 5% and 40% of nominal maximum SAA effect |
| 6-19 | Unused | | |
| 20 | Maneuver Flag | WARNING | Indicates a spacecraft attitude maneuver was in progress during the measurement |
| 21 | Attitude Threshold Flag | WARNING | Indicates any of the 3 geodetic spacecraft attitude Euler angles exceeds a defined threshold |
| 22-31 | Unused | | |

## 3.3.2 ScienceData Group

| Dataset Name | Description | Dimensions | Units |
|---|---|---|---|
| Chlorophyll | Climatological chlorophyll concentration | DimAlongTrack, DimCrossTrack | mg/m^3 |
| CloudFractionforO3 | Effective cloud fraction | DimAlongTrack, DimCrossTrack | (unitless) |
| CloudPressureforO3 | Effective cloud pressure, a.k.a. optical centroid pressure | DimAlongTrack, DimCrossTrack | hPa |
| CloudPressureforO3_uncorrected | Effective cloud pressure, a.k.a. optical centroid pressure, before adjusting for cross-track bias | DimAlongTrack, DimCrossTrack | hPa |
| Convergence_factor | Convergence factor | DimAlongTrack, DimCrossTrack | (unitless) |
| Filling-In | Filling -in factor | DimAlongTrack, DimCrossTrack | (unitless) |

| | | | |
|---|---|---|---|
| MeasurementQualityFlags | The measurement quality flag associated with each "scan" line<br><br>Bit 0 - Measurement Missing Flag: All ground pixels have L1B PixelQualityFlags bit 0 set.<br><br>Bit 1 - Measurement Error Flag: Any of L1B MeasurementQualityFlags bit 0, 1 or 3 are set for radiance or solar product used.<br><br>Bit 2 - Measurement Warning Flag: Any of L1B MeasurementQualityFlags bit 2, 4, 5, 8, 9 are set for radiance or solar product used<br><br>Bit 3 - Rebinned Measurement Flag: L1B radiance MeasurementQualityFlags bit 7 is set.<br><br>Bit 4 - SAA Flag: L1B MeasurementQualityFlags bit 10 is set for radiance or solar product used.<br><br>Bit 5 - Spacecraft Maneuver Flag: L1B MeasurementQualityFlag bit 11 is set for radiance or solar product used.<br><br>Bit 6 - Instrument Setting Error Flag: Values for Earth and solar InstrumentConfigurationId are not compatible.<br><br>Bit 7 - To be defined (currently set to 0). | DimAlongTrack | (no units) |
| ProcessingQualityFlags | Bits 0 to 15 contain several processing quality flags:<br>0 – failed convergence check<br>1 – solar zenith angle out of range<br>(SZA > 86 deg)<br>2 – cloud pressure less than low<br>range of table<br>3 – cloud pressure greater than surface pressure<br>4 – matrix inversion failed<br>5 – snow/ice (if second byte of<br>GroundPixelQualityFlags ≥ 50 and ≤ 130)<br>6 - reflectivity < 0 or > 1.0<br>7 - bad radiances detected<br>8 – aerosol index flag<br>9 - radiance PixelQuality error | DimAlongTrack,<br>DimCrossTrack | (no units) |

| | | | |
|---|---|---|---|
| | 10 – radiance PixelQuality warning<br>11 – irradiance PixelQuality error<br>12 – irradiance PixelQuality warning<br>13 – scene pressure retrieved because cloud fraction < 0.05<br>14 – missing data<br>15 – geolocation error<br><br>Important note: most users should reject data when PQF bits 0,1,2,3,4,6,7,13,14,15 are set. | | |
| RadiativeCloudFraction | The radiative cloud fraction | DimAlongTrack, DimCrossTrack | (unitless) |
| Reflectivity | Reflectivity at 354 nm | DimAlongTrack, DimCrossTrack | (unitless) |
| Residual_bias | Residual bias | DimAlongTrack, DimCrossTrack | (unitless) |
| Residual_stddev | Residual standard deviation | DimAlongTrack, DimCrossTrack | (unitless) |
| SurfaceReflectivity | Climatological surface reflectivity | DimAlongTrack, DimCrossTrack | (unitless) |
| TerrainPressure | Climatological terrain pressure | DimAlongTrack, DimCrossTrack | hPa |
| WavelengthShift | Estimate of wavelength shift | DimAlongTrack, DimCrossTrack | nm |
| dIdR | Sensitivity to surface reflectivity | DimAlongTrack, DimCrossTrack | (unitless) |

# 4.0 Options for Reading the Data

There are many tools and visualization packages (free and commercial) for viewing and dumping the contents of HDF5 files. Libraries are available in several programming languages for writing software to read HDF5 files. A few simple to use command-line and visualization tools, as well as programming languages for reading the L2 HDF5 data files are listed in the sections below.

## 4.1 Command Line Utilities

### 4.1.1 h5dump (free)

The h5dump tool, developed by the HDFGroup, enables users to examine the contents of an HDF5 file and dump those contents, in human readable form, to an ASCII file, or alternatively to an XML file or binary output. It can display the contents of the entire HDF5 file or selected objects, which can be groups, datasets, a subset of a dataset, links, attributes, or datatypes. The h5dump tool is included as part of the HDF5 library, or separately as a stand-alone binary tool:

https://portal.hdfgroup.org/display/support/Download+HDF5

### 4.1.2 ncdump (free)

The ncdump tool, developed by Unidata, will print the contents of a netCDF or compatible file to standard out as CDL text (ASCII) format. The tool may also be used as a simple browser, to display the dimension names and lengths; variable names, types, and shapes; attribute names and values; and optionally, the values of data for all variables or selected variables. To view HDF5 data files, version 4.1 or higher is required. The ncdump tool is included with the netCDF library. **NOTE: you must include HDF5 support during build.**

https://www.unidata.ucar.edu/downloads/netcdf/

### 4.1.3 H5_PARSE (IDL/commercial)

The H5_PARSE function recursively descends through an HDF5 file or group and creates an IDL structure containing object information and data values. You must purchase an IDL package, version 8 or higher, to read the L2 HDF5 data files.

https://www.harrisgeospatial.com/Software-Technology/IDL

## 4.2 Visualization Tools

### 4.2.1 HDFView (free)

HDFView, developed by the HDFGroup, is a Java-based graphic utility designed for viewing and editing the contents of HDF4 and HDF5 files. It allows users to browse through any HDF file, starting with a tree view of all top-level objects in an HDF file's hierarchy. HDFView allows a user to descend through the hierarchy and navigate among the file's data objects. Editing features allow a user to create, delete, and modify the value of HDF objects and attributes. For more info see:

https://portal.hdfgroup.org/display/support/Download+HDFView

### 4.2.2 Panoply (free)

Panoply, developed at the Goddard Institute for Space Studies (GISS), is a cross-platform application which plots geo-gridded arrays from netCDF, HDF and GRIB dataset required. The tool allows one to slice and plot latitude-longitude, latitude-vertical, longitude-vertical, or time- latitude arrays from larger multidimensional variables, combine two arrays in one plot by differencing, summing or averaging, and change map projections. One may also access files remotely into the Panoply application.

https://www.giss.nasa.gov/tools/panoply/

### 4.2.3 H5_BROWSER (IDL/commercial)

The H5_BROWSER function presents a graphical user interface for viewing and reading HDF5 files. The browser provides a tree view of the HDF5 file or files, a data preview window, and an information window for the selected objects. The browser may be created as either a selection dialog with Open/Cancel buttons, or as a standalone browser that can import data to the IDL main program. You must purchase an IDL package, version 8 or higher to view the L2 HDF5 data files.

https://www.harrisgeospatial.com/Software-Technology/IDL

## 4.3 Programming Languages

Advanced users may wish to write their own software to read HDF5 data files. The following is a list of available HDF5 programming languages:

Free:

C/C++, Fortran (https://portal.hdfgroup.org/display/support/Downloads)

Java (https://portal.hdfgroup.org/display/support/HDF-Java)

Python (https://www.h5py.org/)

GrADS (http://cola.gmu.edu/grads/)

Commercial:

IDL (https://www.harrisgeospatial.com/Software-Technology/IDL)

Matlab (https://www.mathworks.com/products/matlab.html)

# 5.0 Data Services

Access of GES DISC data now requires users to register with the NASA Earthdata Login system and to request authorization to “NASA GESDISC DATA ARCHIVE Data Access”. Please note that the data are free of charge to the public.

## 5.1 GES DISC Search

The GES DISC provides a keyword, spatial, temporal and advanced (event) searches through its unified search and download interface:

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

The interface offers various download and subsetting options that suit the user’s needs with different preferences and different levels of technical skills. Users can start from any point where they may know little about a particular set of data, its location, size, format, etc., and quickly find what they need by just providing relevant keywords, such as a data product (e.g. “OMPS”), or a parameter such as “ozone”.

## 5.2 Direct Download

The OMPS data products may be downloaded in their native file format directly from the archive using https access at:

https://omps.gesdisc.eosdis.nasa.gov/data/

## 5.3 OPeNDAP

The Open Source Project for a Network Data Access Protocol (OPeNDAP) provides remote access to individual variables within datasets in a form usable by many OPeNDAP enabled tools, such as Panoply, IDL, Matlab, GrADS, IDV, McIDAS-V, and Ferret. Data may be subsetted dimensionally and downloaded in a netCDF4, ASCII or binary (DAP) format. The GES DISC offers the OMPS data products through OPeNDAP:

https://omps.gesdisc.eosdis.nasa.gov/opendap/

# 6.0 More Information

## Contact Information


Name: GES DISC Help Desk
URL: https://disc.gsfc.nasa.gov
E-mail: gsfc-help-disc@lists.nasa.gov
Phone: 301-614-5224
Fax: 301-614-5228
Address: Goddard Earth Sciences Data and Information Services Center
Attn: Help Desk
Code 610.2
NASA Goddard Space Flight Center Greenbelt, MD 20771 USA


## Additional OMPS and ozone data products

https://ozoneaq.gsfc.nasa.gov/

## Joint Polar Satellite System

https://www.jpss.noaa.gov/

# 7.0 Acknowledgements

These data should be acknowledged by citing the product in publication reference sections as follows:

Joanna Joiner and Alexander Vasilkov (2020), OMPS-NPP NMCLDRR- L2, Greenbelt, MD, USA, Goddard Earth Sciences Data and Information Services Center (GES DISC), accessed ***[data access date]***, doi:10.5067/0WF4HAAZ0VHK.

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