OMPS Nadir Mapper Level 3 Description

1. Purpose and Scope

The purpose of this document is to provide an overview of the OMPS-NPP Nadir Mapper Level 3 data product format for its users. The NMTO3-L3-DAILY APP grids L2 total ozone, reflectivity, and UV aerosol index into a 1 degree x 1 degree grid.

2. 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).

3.0 Algorithm Background

NMTO3-L3-DAILY is based upon the TOMS Level 3 Gridded Software routine described in McPeters et al.

The level-3 gridding algorithm is used to combine the orbital OMPS cross track measurements into a daily map product with a fixed global grid. The adopted L3 grid is a 1.0-degree by 1.0-degree grid in longitude and latitude. The dimensions of the grid are 360 by 180. The center of the first grid cell is located at longitude -179.5 and latitude -89.5. The center of the final grid cell is located at longitude 179.5 and latitude 89.5. The center of the grid itself is located at longitude 0.0 and latitude 0.0, and corresponds to the corners of four grid cells.

At higher latitudes where orbital overlap occurs, only the average from the orbit that provides the best view of a given cell is reported. In practice, cell averages are computed separately for each orbit and the one with the shortest average path index is selected. The path index is calculated as $\sec(\theta_0) + 2\sec(\theta)$, where θ_0 and θ are the solar zenith and spacecraft zenith angles respectively, defined as the Instantaneous Field-of-View (IFOV). This index is designed to place more importance on the spacecraft zenith angle than on solar zenith angle relative to the proper calculation of geometric path ($\sec(\theta_0) + \sec(\theta)$).

The cell averages are computed as weighted averages of a given parameter derived for IFOVs that overlay the given cell. For this purpose, a simple rectangular model is used for the actual IFOV. The fractional area of overlap of the rectangular IFOV with a given ceil is used to weight its contribution to the given grid cell average. A single IFOV can contribute weight to more than one cell average within a single 1 degree latitude band. *Any* IFOV with its center outside the latitude band is ignored as a simplification to the calculation.

NMTO3-L3-DAILY is non-synoptic. On polar-orbiting satellites (such as Suomi-NPP, which has OMPS onboard), all measurements are made at a local time roughly equal to the Local Equator Crossing Time (LECT). The Western Pacific is measured near the beginning of the Greenwich Mean Time (GMT) day, and the Eastern Pacific is measured near the end of the GMT day. There is a 24- hour discontinuity in the data at 180th meridian. Individual IFOVs are sorted into different days across the 180th meridian to ensure that this is the only place where such a time discontinuity occurs. In order to accomplish this while providing a complete global map, some data from the previous GMT day are used at the beginning of our Level-3 day and some data

from the next GMT day are used at the end. The LECT for each daily global file is provided in the output data.

3.1 Gridding Criteria

The L2 observation exclusion criteria are summarized here in sequence.

A1) As a rough first cut, L2 observations made outside of the 48-hour time interval centered at noon UTC day are excluded.

At any given moment, all points on Earth between the longitude of midnight and the dateline that are on the same side of the dateline have the same calendar date. The calendar dates on opposite sides of the dateline differ by one day, except at the instant when the longitude of midnight and the dateline coincide, in which case the date is the same everywhere on Earth.

A2) L2 observations with local calendar dates on the ground that correspond to the day before the TOMS L3 day are excluded.

A3) L2 observations with local calendar dates on the ground that correspond to the day after the TOMS L3 day are excluded.

A4) L2 observations with the solar eclipse possibility flag set are excluded.

After this point there are significant differences in how L2 observations are excluded from the L3 grids for the total column amount ozone and radiative cloud fraction, and 2) the L3 grid for the UV aerosol index.

Total Column Ozone and Radiative Cloud Fraction, and Reflectivity

There are two criteria in addition to A1 through A5 (above) for excluding L2 observations from the L3 grids for the total column amount ozone and radiative cloud fraction.

The L2 QualityFlags have the following values:

0 - good sample
1 - glint contamination (corrected)
2 - sza > 84 (degree)
3 - 360 residual > threshold
4 - residual at unused ozone wavelength > 4 sigma
5 - SOI > 4 sigma (SO2 present)
6 - non-convergence
7 - abs(residual) > 16.0 (fatal)
Add 8 for descending data.

B5) L2 observations gathered on the ascending part of the orbit that are not either a "good sample" or "glint contamination corrected" are excluded, as are all observations gathered on the descending part of the orbit.

B7) The path index is somewhat arbitrarily defined to be $1.0 / \cos(\theta_0)) + 2.0 / \cos(\theta)$, where θ and θ are the solar zenith and viewing zenith angles of the observation, respectively.

For any L3 grid cell that has a path index range exceeding 14.0, L2 observations that have a path index greater than or equal to the average value in the grid cell are excluded.

The implementation of this criterion, of course, requires two passes through the L2 observations. The first pass through calculates the path index range and average for all of the candidate L2 observations in each L3 grid cell.

With this information in hand, the second pass through then applies the criterion to exclude L2 observations from each L3 grid cell.

UV Aerosol Index

There are five criteria in addition to A1 through A5 (above) for excluding L2 observations from the L3 grid for the UV aerosol index.

C6) L2 observations gathered on the descending part of the orbit or with the "non-convergence" flag set are excluded.

C7) L2 observations with a solar zenith angle greater than or equal to 70.0 degrees are excluded.

C8) L2 observations with a path index greater than or equal to 7.0 are excluded.

C9) Thje glint angle is equal to the inverse cosine of

$(\cos(\theta_0) * \cos(\theta) + \sin(\theta_0) * \sin(\theta) * \cos(\phi))$

where ϕ is the relative azimuth angle of the observation. L2 observations with water at the ground pixel center and a glint angle less than or equal to than 20.0 degrees are excluded.

C10) L2 observations with a value of the UV aerosol index equal to the missing value (to within one part in a thousand) are excluded

C11) Values of the UV aerosol index less than 0.5 are excluded.

4. What's New?

V2.1 is the first version of the dataset released through the GES DISC. The previous V1.0 dataset was available through NASA's OMPS science team's web site:

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

Changes from V1.0 to V2.0 include:

Non science related changes

Nomenclature and Naming Convention

1) The naming convention for the L3 dataset has been changed from TC_EDR_TOC_DAILY to NMTO3-L3-DAILY
    a. TC (Total Column) has been replaced by NM (Nadir Mapper).
    b. NOAA nomenclature (EDR) has been replaced by NASA nomenclature (L3).
2) All capitalization of names within the file has been replaced by camel casing.
3) Underlines in all names have been eliminated.

Science related changes

1) The V2.1 dataset uses V2.1 of NMTO3-L2 as input.

5. 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 = NMTO3
- level = 3
- 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 examples:

OMPS-NPP_NMTO3-L3-DAILY_v2.1_2017m0213_2017m0227t092659.h5

OMPS-NPP_NMTO3-L3-DAILY-Ozone-ASCII_v2.1_2017m0213_2017m0227t092713.txt

OMPS-NPP_NMTO3-L3-DAILY-UVAerosolIndex-ASCII_v2.1_2017m0213_2017m0227t092713.txt

6. File Formats and Structure

NMTO3-L3-DAILY data files are provided in the HDF5 format (Hierarchical Data Format Version 5), developed at the National Center for Supercomputing Applications http://www.hdfgroup.org/. These files use the Swath data structure format.

The first OMPS NMEV measurements used to create the NMEV-L1B product were taken on January 28, 2012. Data for February-March 2012 have numerous gaps due to variations in instrument. 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 July 2016.

Besides HDF5 format, two separate ASCII files are also provided, one for total column ozone and one for UV aerosol index. The ASCII files follow the format used for TOMS data. The first three lines are header information which includes the date the data were taken, the instrument, the type of processing (eg., production, near real time, etc), the feature of study (ozone or aerosols), the generation date of the file, and the local equator crossing time of the satellite. Data values at 360 longitudes for each latitude centered at -89.5 degrees are given. The next 360 values are given for the latitude centered at -88.5 degrees and so on. For the ozone files, zeros denote missing or flagged data, i.e. data that could not be collected due to lack of sunlight or other problems for ozone. In the case of aerosols, "999" is used for missing or flagged data

6. Products/Parameters

Dataset Name	Description	Units
ColumnAmountOzone[1]	Total column ozone amount	DU
LandSeaMask	0 over water, 1 over land	No units
Latitude	Latitudes of the center for the pixels (-89.5 to 89.5)	Degrees
Longitude	Longitudes of the centers for the pixels (-189.5 to 1809.5)	Degrees
Longitude	Ground pixel longitude	Degrees
Percent water	Percentage of pixel covered by water	Percent
RadiativeCloudFraction	Radiative cloud fraction	No units
Reflectivity331	Reflectivity determined from the 331 nm wavelengths	No units
SolarZenithAngle	Average solar zenith angle of the grid cell	Degrees

UVAerosolIndex[2]	UV aerosl index	Degrees
ViewingZenithAngle	Average viewing zenith angle of the grid ceall	Degrees
GroundPixelQualityFlags	SAA, eclipse, Sun glint, terrain type flags	No Units

1Only value contained in

2Only value contained in

7. References

Richard D. Mcpeters, P.K. Bhartia, Arlin J. Krueger, and Jay R. Herman, “Total Ozone Mapping Spectrometer (TOMS) Level-3 Data Products User’s Guide, NASA/TP-2000-209296.