OMPS Limb Profiler - Daily Ozone Product Description

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Introduction

This document describes the content and format of the daily ozone profile product files created from Ozone Mapping and Profiler Suite (OMPS) Limb Profiler (LP) measurements. This product is referred to as LP-L2-O3-DAILY throughout this document. OMPS LP views the Earth's limb looking backwards along the orbit track, using three parallel vertical slits. One slit is aligned with the orbit track, and the other two slits are pointed 4.25° to each side, giving an effective cross-track separation of approximately 250 km at the tangent point. Each profile measurement takes approximately 19 seconds to complete, corresponding to along-track sampling of approximately 125 km. Further instrument technical details and retrieval algorithm description can be found in *Jaross et al.* [2012] and *Rault and Loughman* [2013].

1. LP-L2-O3-DAILY Product

The LP-L2-O3-DAILY product contains a subset of the retrieval information that is available in the orbital Level 2 LP-L2-O3 data product. The orbital products are not currently released to the public. The daily product is simply an aggregation of retrieval results over all orbits whose starting time [UT] falls within a single calendar day. The ozone product consists of retrieved ozone density profiles for every observation (termed "event" in this document), together with appropriate geolocation data and informational flags. Separate retrievals are performed (for overlapping altitude ranges) using radiance data at ultraviolet (UV) and visible (VIS) wavelengths, and a combined ozone profile for each event is created from these individual retrievals. Each profile is also reported in mixing ratio format on a regular pressure grid for user convenience.

1.1. File Format

The LP-L2-O3-DAILY data files are provided in the HDF5 format. The hdf5 library is required to read the files. This library is available from http://hdfgroup.org. In addition to interfaces in C and FORTRAN which are developed and distributed by the HDF Group, there is a high quality interface for Python called h5py. These options are all open source format. The ability to read

HDF5 files is also included in many common commercial data analysis tools, such as Matlab, IDL, TecPlot, and Mathematica. An HDF5 file consists of named groups (which behave like folders or directories in a computer file system) and named datasets. Because the objects are named, they can be accessed by name rather than by file offset.

1.2. Groups and Datasets

The LP-L2-O3-DAILY data file consists of three primary groups (h5 space): the AncillaryData group, the DataFields group, and the GeolocationFields group. Each group contains multiple datasets that correspond to the group category. The contents of these groups are summarized in the following sections. Tables 1-3 provide a brief description for each dataset name. In many cases, this description matches the "long name" contained in the HDF5 file. Some descriptions have been simplified because the legacy long name transferred from Level 1B (L1B) or Level 1 gridded (L1G) files is more difficult to understand. We anticipate revising the long names themselves for future releases.

1.2.1. AncillaryData Group

The AncillaryData group contains the background atmosphere pressure profile, the background atmosphere temperature profile, the terrain altitude, and the tropopause altitude datasets. The temperature and pressure profiles are interpolated in time from the closest GMAO gridded data profiles (see Release Notes for details) to the tangent point location of each OMPS LP event. The tropopause altitude is also determined from the external data. Table 1 summarizes the dataset name, description, units and dimension of these four datasets. In the following tables, note that while there are *ntime* observations during a given day, the dimension size *ntime**3 incorporates the three slits used by the LP instrument.

Dataset name	Description	Unit	Dimension
AtmospherePressure	Atmospheric pressure	hPa	(ntime*3, 61)
AtmosphereTemperature	Atmospheric temperature	C	(ntime*3, 61)
TerrainAltitude	Terrain altitude above mean sea level	km	(ntime*3)
TropopauseAltitude	Tropopause altitude	km	(ntime*3)

Table 1. The AncillaryData group contents: Dataset name, description, unit and dimension.

1.2.2. DataFields Group

The DataFields group contains the aerosol scattering index (ASI) values and flags, the retrieved tropospheric cloud height (if any), the image number (referred to as "frame"), the slit number, the residual flag, the ozone density profiles and estimated precision, the ozone mixing ratio profiles, the quality flag, the sample table version, and the surface reflectance.

Aerosol Scattering Index (ASI). The aerosol scattering index uses radiance residuals, which are the difference between observed radiance values and synthetic radiance values calculated by a radiative transfer model for the conditions of each measurement. ASI values are calculated by normalizing the residuals for specific wavelengths at a reference altitude.

$$ASI(\lambda,z) = residual(\lambda,z) - residual(\lambda,45.5\ km)$$

Calculated ASI profiles are provided at two separate wavelengths (353 nm, 674 nm). Three different diagnostic flags are set based on these results.

ASI Aerosol Flag. This flag is set to 1, indicating possible aerosol effects in the UV ozone retrieval, if ASI_353 > 0.05 at 27.5 km.

ASI PMC Flag. This flag is set to 1, indicating possible polar mesospheric cloud (PMC) effects in the UV ozone retrieval, if ASI_353 > 0.20 at 65.5 km.

ASI Pressure Flag. This flag is set to 1, indicating a possible error in the ancillary data pressure profile, if abs[ASI_353] > 0.10 at any altitude between 28-60 km.

Cloud Height. The cloud height is determined by the retrieval algorithm if a cloud is detected for that event.

Frame Number. The frame number represents the position of each frame during each orbit sequence, beginning at 1 and ending at the last frame for that orbit.

Ozone Density Profiles. Separate ozone density profile retrievals are performed using UV data and VIS data. The UV ozone retrieval is performed over the altitude range 27.5-60.5 km. For the visible ozone retrieval, the lowest valid altitude is set to be 1 km above the cloud height (if detected). The highest valid altitude of the VIS retrieval is determined by the signal to noise ratio (SNR) of the measurements, but typically lies between 30-35 km.

Ozone Profile Precision. This quantity is the estimated standard deviation derived from the diagonal of the covariance matrix of the Rodgers optimal estimation solution for each retrieval.

Ozone Profile Quality. The quality flag is set to 1.0 for a successful retrieval, or -999.0 for an unsuccessful retrieval.

Combined Ozone Density Profile. For the combined ozone density profile, the VIS retrieval results are used between 0-26.5 km, and the UV retrieval results are used between 27.5-60.5 km. No merging or adjustment is performed at the transition altitude.

Ozone Mixing Ratio Profile. Each ozone density profile is converted to mixing ratio using the appropriate pressure and temperature profiles from the ancillary data, and then interpolated to the regular pressure grid.

Residual Flag. This flag contains information about possible South Atlantic Anomaly (SAA) or polar mesospheric cloud (PMC) effects on each retrieval, based on the evaluation of UV radiance residuals. The average residual is calculated at each wavelength over the altitude range used in the retrieval, and if a maximum difference greater than 0.10 is identified at any altitude, the flag is set. Reported flag values have the following meanings.
-1 = No Level 2 residuals.
0 = No effects identified.
1 = Maximum difference has opposite sign from neighboring wavelengths ("spike"), consistent with SAA effects. NOTE: This flag is set based on particle hit effects on the CCD, but the event tangent point location reported in this file is approximately 25 degrees further south in latitude.
2 = Maximum difference has same sign as neighboring wavelengths, consistent with PMC effects. Note that most PMC effects are expected to occur in polar summer conditions (60°-85°N during June-August, 60°-85°S during December-February).

Sample Table Version. This field identifies the LP instrument sample table used to collect data for each event. Due to satellite limitations on data rate, only a subset of CCD pixels (specified by altitude, wavelength, gain, and integration time) are downloaded for each measurement.

Slit Number. The slit number is defined as 1 = left slit, 2 = center slit, 3 = right slit. The sequence of values in this dataset for a given day is 1, 1, 1,…1 for the first *ntime* events, followed by 2, 2, 2,…2 for the next *ntime* events, and 3, 3, 3,…3 for the last *ntime* events.

Surface Reflectance. The surface reflectance is the effective scene reflectance at 524 nm, considering any clouds as being present at the terrain height.

Dataset name	Description	Unit	Dimension
ASI353Value	Calculated aerosol scattering index (ASI) using 353 nm residuals	unitless	(ntime*3, 61)
ASI674Value	Calculated aerosol scattering index (ASI) using 674 nm residuals	unitless	(ntime*3, 61)

ASI_AerosolFlag	ASI flag for aerosol impact on ozone retrieval	unitless	(ntime*3)
ASI_PMCFlag	ASI flag for PMC impact on ozone retrieval	unitless	(ntime*3)
ASI_PressureFlag	ASI flag for pressure error in ancillary data	unitless	(ntime*3, 33)
ASI_PressureAltGrid	Altitude grid for ASI pressure flag	km	(33)
CloudHeight	Cloud height	km	(ntime*3)
FrameNumber	Frame index for each orbit	unitless	(ntime*3)
O3CombinedPrecision	Combined ozone density profile precision	cm^{-3}	(ntime*3, 61)
O3CombinedQuality	Quality flag for success of combined ozone density profile	unitless	(ntime*3)
O3CombinedValue	Combined ozone density profile values	cm^{-3}	(ntime*3, 61)
O3Combined_FOV_FWHM	Combined ozone density profile resolution (FWHM) in height	km	(ntime*3, 61)
O3UvPrecision	UV retrieval ozone density profile precision	cm^{-3}	(ntime*3, 61)
O3UvQuality	Quality flag for success of UV ozone retrieval	unitless	(ntime*3)
O3UvValue	UV retrieval ozone density profile values	cm^{-3}	(ntime*3, 61)
O3VisPrecision	Visible retrieval ozone density profile precision	cm^{-3}	(ntime*3, 61)
O3VisQuality	Quality flag for success of visible ozone retrieval	unitless	(ntime*3)
O3VisValue	Visible retrieval ozone density profile values	cm^{-3}	(ntime*3, 61)
O3VmrCombinedPrecision	Combined ozone mixing ratio profile precision	ppmv	(ntime*3, 61)
O3VmrCombinedValue	Combined ozone mixing ratio profile values	ppmv	(ntime*3, 61)
O3VmrUvPrecision	UV retrieval ozone mixing ratio profile precision	ppmv	(ntime*3, 61)
O3VmrUvValue	UV retrieval ozone mixing ratio profile values	ppmv	(ntime*3, 61)
O3VmrVisPrecision	Visible retrieval ozone mixing ratio profile precision	ppmv	(ntime*3, 61)
O3VmrVisValue	Visible retrieval ozone mixing ratio profile values	ppmv	(ntime*3, 61)
ResidualFlag	Flag to indicate possible South Atlantic Anomaly or PMC impact based on residuals	unitless	(ntime*3)
SlitNumber	Slit index for each event	unitless	(ntime*3)
STBversion	Sample table version used for data collection	unitless	(ntime*3)
SurfaceReflectance	Mean surface reflectance	unitless	(ntime*3)

Table 2. The DataFields group contents: Dataset name, description, unit and dimension.

1.2.3. GeolocationFields Group

The GeolocationFields data group contains the date and time of each measurement, the reference height scale for ozone density profiles, the orbit number, the pressure grid for ozone mixing ratio profiles, some individual event information flags, and the following values determined at 25 km tangent height: latitude, longitude, single scattering angle, and solar zenith angle.

Height Scale. The height scale gives the altitude grid used for LP-L2-O3-DAILY products. Data are reported at 1 km intervals over the range 0.5, 1.5, …60.5 km.

Pressure Grid. The pressure grid gives 16 levels per decade of pressure for mixing ratio products, using the conversion formula $z^* = 16*\log(1013/P)$.

Swath Level Quality Flags. The swath level quality flag contains five values in the form '*abcde*', with the following definitions.

a: SAA (South Atlantic Anomaly)
- 0 = estimated SAA effects at satellite location are < 5% of nominal maximum value, based on OMPS LP climatology
- 1 = estimated SAA effects at satellite location are 5-40% of nominal maximum value
- 2 = estimated SAA effects at satellite location are 40-75% of nominal maximum value
- 3 = estimated SAA effects at satellite location are > 75% of nominal maximum value

b: Moon
- 0 = does not appear in any slit (based on calculated ephemeris)
- 1 = appears in left slit
- 2 = appears in center slit
- 3 = appears in right slit

c: SolarEclipse
- 0 = none
- 1 = solar eclipse on day side of Earth at time of measurement

d: OtherPlanets
- 0 = does not appear in any slit (based on calculated ephemeris)
- 1 = appears in left slit
- 2 = appears in center slit
- 3 = appears in right slit

e: NonNominalAttitude
- 0 = nominal spacecraft attitude
- 1 = attitude shift due to planned spacecraft maneuver (such as roll or yaw) or other reason

The climatology for estimating SAA effects was developed using LP closed-door measurements of charged particle hits on the CCD made from November 2011 to January 2012. A two-dimensional Gaussian fit was used to parameterize the observations for operational use [*Jaross et al.*, 2014]. Please note that this flag is set during L1B processing based on spacecraft position, rather than the tangent point location of any LP slit. A simplified representation of SAA geographic coverage for significant impact on the retrieved ozone profile is given by the following coordinates:

Latitude = [55°S, 10°N] Longitude = [115°W, 37.5°E]

Dataset name	Description	Unit	Dimension
Date	Date	YYYYMMDD	(1)
HeightScale	Reference height scale for retrievals	km	(61)
Latitude	Mean latitude at tangent height of 25 km	degrees	(ntime*3)
Longitude	Mean longitude at tangent height of 25 km	degrees	(ntime*3)
OrbitNumber	Orbit number	unitless	(ntime*3)
PressureGrid	Pressure grid with equal steps (16 levels per decade of pressure) for mixing ratio data	hPa	(61)
SingleScatteringAngle	Mean single scattering angle at tangent height of 25 km	degrees	(ntime*3)
SolarZenithAngle	Mean solar zenith angle at tangent height of 25 km	degrees	(ntime*3)
SwathLevelQualityFlag	Flags for satellite location and orientation	unitless	(ntime*3)
Time	Seconds since midnight [UT]	seconds	(ntime*3)

Table 3. The GeolocationFields group contents: Dataset name, description, unit and dimension.

1.3. Product Filenames

The product file name follows the pattern of the sample below for data collected on April 2, 2012:

OMPS-NPP_LP-L2-O3-DAILY_v2.0_2012m0402_2014m0512t102007.h5

---Product name--- ---Date--- ---Processing Time---

2. References

Jaross, G., G. Chen, M. Kowitt, J. Warner, P. Xu, T. Kelly, M. Linda, and D. Flittner [2012], Suomi NPP OMPS Limb Profiler initial sensor performance assessment, *Proc. SPIE*, *8528*, doi:10.1117/12.979627.

Jaross, G., P. K. Bhartia, G. Chen, M. Kowitt, M. Haken, Z. Chen, P. Xu, J. Warner, and T. Kelly [2014], OMPS Limb Profiler instrument performance assessment, *J. Geophys. Res. Atmos.*, *119*, doi:10.1002/2013JD020482.

Rault, D. F., and R. P. Loughman [2013], The OMPS Limb Profiler Environmental Data Record Algorithm Theoretical Basis Document and expected performance, *IEEE Trans. Geosci. Rem. Sens.*, *51*, 2505-2527.