# LP-L2-O3-DAILY – Version 2 Data Release Notes

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The OMPS Limb Profiler (LP) Version 2 daily ozone product was created using a modified version of the ozone retrieval algorithm described in *Rault and Loughman* [2013]. The algorithm generates ozone density *vs.* altitude profiles at every 1 km interval between 0-60 km, with a vertical resolution of ~1.8 km. The algorithm uses altitude-normalized radiances to make the retrievals insensitive to both instrument calibration errors and to the diffuse upwelling radiation (DUR) produced by surface reflection and scattering of sunlight by clouds and aerosols located below the tangent point. The UV algorithm retrieves profiles between 27 km and 60 km, using radiances at wavelengths between 289-325 nm normalized at 65.5 km. Each wavelength is paired with 353 nm to make the algorithm insensitive to errors in the assumed pressure *vs.* altitude profiles p(z) used in calculating the radiances. The VIS algorithm retrieves profiles from cloud top to approximately 30-35 km, using radiances at wavelengths between 549-633 nm normalized at 45.5 km. Each wavelength is combined with 510 nm and 673 nm to form a triplet. In addition to making the algorithm insensitive to p(z), triplets greatly reduce the sensitivity of the algorithm to aerosols. In creating the combined ozone profiles, we cut off the VIS profiles at 26.5 km and provide UV profiles above 27.5 km.

While the LP algorithm does not directly retrieve ozone mixing ratio *vs.* pressure profiles, we provide them in the Level 2 (L2) files for the convenience of users. To do the conversion, we use temperature and pressure profiles from NASA Global Modeling and Assimilation Office (GMAO) GEOS-5 FP-IT Np gridded data, which are provided on 42 pressure levels up to 0.1 hPa, at 0.5° latitude x 0.625° longitude horizontal resolution, and at 3 hours temporal interval.

The LP-L2-O3-DAILY data files represent a subset of the L2 orbital file information, concatenated into a single HDF file for each day. These files contain ozone density and mixing ratio profiles for each event, along with geolocation information and informational flags. More details about the contents are given in the daily ozone Product Description document.

**Changes Between Version 1 and Version 2 Data Product**

Numerous changes have been implemented for the LP V2 ozone product compared to the V1 product. These changes are summarized below.

- The baseline wavelength registration has been revised. In addition, spectral shifts due to temperature variations are now corrected using a seasonal term (based on the day of year for each measurement) and an intra-orbit term (applied within each orbit).
- The *a priori* data set is now based on 2012 MLS observations.
- An estimated instrument error of 1% has been incorporated in the retrieval procedure to reduce high frequency vertical oscillations in the retrieved profiles.
- Radiance samples between 306.5-311 nm are excluded from the UV ozone retrieval to avoid contamination from OH dayglow emission at high altitudes.

- Data are reported from all three LP slits.
- The normalization altitude for radiance data used in the UV ozone retrieval has been lowered from 68.5 km to 65.5 km.
- No aerosol correction is applied in the ozone retrieval based on external aerosol profile data.
- The combined ozone profile does not apply any merging procedure in the altitude region where the UV and visible retrievals overlap. UV ozone data are used from 60.5 km down to 27.5 km, and visible ozone data are used from 26.5 km down to the lowest altitude retrieved for that event.

**Version 2 Data Quality Summary**

Preliminary comparisons of LP V2 ozone data with Aura MLS data show that in general, the quality of VIS profiles is quite high. The UV profiles have a few data quality issues that are described below.

Tangent Height. While the Suomi NPP spacecraft has a star tracker that provides accurate pointing information, it is located near the VIIRS instrument at the opposite end of the spacecraft from the OMPS sensors. Our preliminary analysis indicates that the flexure of the spacecraft bus may be causing up to 20 arc-sec errors in determining the spacecraft pitch angle at the OMPS LP location, which can produce up to 300 m error in determining the altitude at the LP tangent point. These errors vary with latitude and season, and can produce up to 10% error in ozone density retrieved by the UV algorithm. The errors are relatively small in the altitude range covered by the VIS profiles, since the vertical gradient of ozone density there is less steep.

Aerosols. The V2 ozone algorithm does not use an explicit aerosol correction. However, the VIS algorithm, which uses wavelength triplets, is relatively insensitive to aerosols compared to the UV algorithm that uses wavelength pairs. In the VIS algorithm the aerosol errors typically occur in the lower stratosphere where the aerosol extinction becomes large enough to reduce the ozone airmass factor along the line of sight (LOS). Comparison with Aura MLS shows that these errors are much smaller than the ozone variability, so they can only be observed after averaging a large number of profiles. The ozone zonal mean values just above the tropopause are typically smaller by about 10% compared to MLS. The UV algorithm, which uses wavelength pairs, is more sensitive to aerosols, particularly to polar mesospheric clouds (PMC). Even though these clouds exist at 80-85 km, they can affect the retrieved ozone densities to altitudes as low as 40 km, if they are in the LOS of the instrument. PMCs are a seasonal phenomenon, generally observed in summer months at latitudes greater than 50°. We have flagged the data most affected by these effects. The flagged data should not be used in data analysis.

Retrieval Altitude Range. In the UV algorithm, a given wavelength is used over a limited altitude range. The lower limit of this range is determined by the altitude where the ozone absorption and/or Rayleigh attenuation along the LOS becomes too large. Our analysis indicates that in the V2 algorithm this altitude limit is set too low. This error causes the retrieved ozone to be overestimated by up to 10% at some altitudes.

Anomalous Low Density Values at High Altitudes. LP ozone density profiles sometimes show anomalously low density values (less than $1.0x10^8$ $cm^{-3}$) in the 55-60 km altitude region. We are still investigating the cause of this error.

Anomalous NH Ozone Values in Right Slit. LP ozone values from right slit measurements have some problems at specific altitudes during a limited subset of the observation range (Sample Table v0.4 = 9/20/2012-11/26/2013, event number greater than approximately 145-150 = 60°-85°N in July, 40°-70°N in December). Ozone density values are 20-50% higher than expected between approximately 35-43 km for these events, and 20-40% lower than expected between 27-33 km. We believe that these deviations are caused by anomalous radiance values.

Inter-Slit Differences. The LP ozone data show some consistent differences between results from the three slits. Left slit ozone values are typically 5-10% higher than center slit values above ~40 km, and are ~10% lower between 15-20 km in the tropics. Similarly, right slit ozone values are typically 5-10% lower than center slit values above ~40 km, and are ~10% higher between 15-20 km in the tropics. We believe that these differences are primarily caused by remaining biases in tangent height registration between the three slits. Comparison of LP ozone values with other data sets do not currently indicate which slit may give the most accurate absolute results.

Data Sampling. Data rate limitations on the Suomi NPP satellite prevent collection of the full wavelength and altitude range observed by LP for every event. The selection of pixels to be downloaded is specified by the Sample Table, which can be reprogrammed on-orbit. Table 1 gives a list of the main sample tables used by the LP instrument since launch. During the time period covered by Sample Table (STB) v0.5 (11/26/2013 – 01/23/2014), the altitude coverage of short wavelength radiance data was not sufficient to provide accurate UV profiles. As a result, we currently do not provide daily LP ozone products for this time period. We plan to develop a modified UV retrieval algorithm that can produce better profiles during this time period.

Data Coverage. The first OMPS LP measurements were taken on January 10, 2012. LP data for January-March 2012 have numerous gaps due to variations in instrument operations and changes in sample tables. Regular operations began on April 2, 2012. Note that there is very little or no LP data on days when the OMPS Nadir Mapper conducts high-resolution measurements. This sequence occurs approximately one day per week, beginning in April 2012.

## Citation Format

Publications that reference these data should include the following citation:
"OMPS LP Version 2 ozone profile data are produced by the LP processing team (DOI 10.5067/suomi-npp/omps-limb/l2-dailyo3/data22)".

## References

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.

| Version | Orbits | Start Date | End Date | Comments |
|---|---|---|---|---|
| 1.2 | 1-1581<br>3735-3737 | 10/28/2011 | 02/16/2012 | BATC sample table |
| 84.4 | 1043-1072 | 01/09/2012 | 01/11/2012 | Initial sample table for regular science operations (ST 5A) |
| 84.3 | 1279-1298 | 01/26/2012 | 01/27/2012 | Left slit only (all pixels) |
| 84.1 | 1299-1386 | 01/27/2012 | 02/03/2012 | Right slit only (all pixels) |
| 84.2 | 1387-1438 | 02/03/2012 | 02/06/2012 | Center slit only (all pixels) |
| 84.5 | 1439-3734<br>3738-4658 | 02/06/2012 | 09/20/2012 | Minor smear pixel revision to operational table |
| 0.4 | 4659-10788 | 09/20/2012 | 11/26/2013 | Minor revision to move wavelength registration columns |
| 0.5 | 10789-11612 | 11/26/2013 | 01/23/2014 | First revision for improved spectral coverage |
| 0.6 | 11613-12010 | 01/23/2014 | 02/20/2014 | Second revision for spectral coverage |
| 0.7 | 12011-13101 | 02/20/2014 | 05/08/2014 | Third revision for spectral coverage |
| 0.8 | 13102-current | 05/08/2014 | current | Small changes to improve IR coverage |

**Table 1.** OMPS LP Sample Table list as loaded on the Suomi NPP spacecraft for Earth view data collection. Note that during early instrument operations (through February 2012), there was more frequent switching between different sample tables.