OMTO3 README File

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Overview

This document provides a brief description of the OMTO3 data product. OMTO3 comprises total ozone and ancillary information produced from the TOMS Version 8.5 (V8.5) algorithm applied to OMI “global mode” measurements [Bhartia and Wellemeyer, 2002]. In the global mode, each file contains a single orbit of data. In each orbit, OMI measurements cover approximately 2600 km wide cross-track swath from pole to pole (sunlit portions only). Currently, OMTO3 data are not produced when OMI goes into “zoom mode”.

The accuracy and precision of the OMTO3 total ozone data are similar to the legacy Total Ozone Mapping Spectrometer (TOMS) data started in 1978, except over cloudy areas where OMTO3 data are more accurate than that of the TOMS. Since there are significant differences between the two products over cloudy areas, users should exercise caution in combining TOMS data with OMTO3 data for long-term trends.

Algorithm Description

The basic algorithm uses 2 wavelengths (317.5 and 331.2 nm under most conditions, and 331.2 and 360.1 nm for high ozone and high solar zenith angle conditions). The longer of the two wavelengths is used to derive effective cloud fraction (fc) based on the Mixed Lambert Equivalent Reflectivity (MLER) model [Ahmad et al. 2004] that was developed to model the effect of clouds on Rayleigh scattering. When fc becomes less than zero or when there is snow/ice, we assume that no cloud is present and use the Lambert Equivalent Reflectivity (LER) model described by Ahmad et al. [2004] to derive the clear scene reflectivity R. When fc exceeds 1, we assume 100 percent cloud cover and derive cloud reflectivity using the LER model. Given the fc/R, the shorter (stronger ozone-absorbing) wavelength is used to derive total ozone.

An important difference between the V8.5 algorithm and previous versions, as well with the archived TOMS dataset, is the assignment of effective cloud height. It has been assumed in the previous algorithms that the absorption of backscattered solar radiation essentially stops at the cloud-top level when the clouds are optically thick. To estimate the total column amount, the “un-measured” column below the cloud-top (computed using climatology) is added to the measured column. Analysis of the OMI data in conjunction with CloudSat radar data [Vasilkov et al. 2008] indicates that this assumption is invalid. Mie scattering calculations using CloudSat data indicate that in all cloudy scenes, including deep convective clouds, the UV radiation received at the satellite is sensitive to the ozone column below the nominal cloud-top pressure reported by thermal infrared sensors such as MODIS. Analysis shows that photons actually penetrate some distance into a cloud. In V8.5, we use the Optical Centroid Cloud Pressure (OCCP) inferred from Rotational-Raman Scattering (OMCLDRR) to derive the total ozone column. Since the pressure corresponding to OCCP is usually significantly below the cloud-top pressure climatology assumed in the V8 algorithm, the V8.5 derived column amounts have decreased over clouds. The magnitude of the decrease depends on cloud fraction, location, and solar zenith angle. Please refer to release specific information about OMTO3 for details.

The effective cloud fraction (fc) derived from the MLER model is used to estimate the Cloud Radiance Fraction (CRF). CRF characterizes the fraction of measured radiation that is scattered by clouds. Mie scattering calculations indicate that the clear and cloudy ozone columns weighted by CRF provides a value very close to what one would calculate from the plane parallel Mie cloud model with the independent pixel approximation to account for mixed scenes. The advantage of the MLER model is that one doesn't need independent knowledge of geometrical cloud fraction to calculate the ozone column accurately in cloudy scenes.

The algorithm also calculates the absorbing Aerosol Index (AI) from the radiance residuals at 360.1 nm. The AI is useful for tracking global transport of smoke and dust, for it can track these aerosols above and through clouds, as well as over snow/ice covered surfaces. Various studies have indicated that AI is very nearly proportional to the aerosol absorption optical depth at 360.1 nm. Though included in the OMTO3 product, an OMI aerosol product (OMAERUV) has since been developed and is the recommended data source for aerosol studies.

Other than the three primary wavelengths mentioned above, the OMTO3 algorithm uses additional wavelengths for quality control and error correction in more restricted geophysical situations. These include correction for ozone profile shape errors at large solar zenith angles using 312.6 nm measurements, and the detection of strong sulfur-dioxide contamination using multiple wavelength pairs. For a more detailed description of the algorithm please refer to the Algorithm Theoretical Basis Document (ATBD) at NASA's Earth Observing System Project Science Office.

The OMTO3 algorithm is one of the two algorithms that derive total ozone values from OMI. The other is an algorithm based on the Differential Optical Absorption Spectroscopy (DOAS) approach that takes advantage of OMI's hyperspectral measurements. The DOAS algorithm is maintained by KNMI of the Netherlands. The DOAS ATBD is also at the above website. The two datasets are generally in good agreement, though some differences still exist in high latitudes and over snow/ice.

Data Quality Assessment

Overall, the quality of total ozone data produced by OMTO3 is similar to that from TOMS, except for cloudy observations, as discussed earlier. Based on experience with TOMS, the total ozone data provided in OMTO3 should have a root-mean squared error of 1-2%, depending on solar zenith angle, aerosol amount, and cloud cover. These errors are best described as pseudo-random: systematic over small areas with a unique geophysical regime, random over large areas containing a mixture of geophysical regimes. Preliminary analyses show that OMTO3 data compare about as well with Dobson and Brewer stations as did Nimbus-7/TOMS data. The overall quality of EP/TOMS data is poorer compared to both Nimbus-7 TOMS and OMI. The EP/TOMS total ozone data have been reprocessed by applying an empirical correction, based on internal consistency criteria for ozone and surface reflectivity and comparisons with NOAA/SBUV-2 data, to remove the effect of several poorly understood instrument anomalies.

Hunga Tonga Eruption, 2022

The eruption of the Hunga Tonga volcano in the southern Pacific was a one of a kind event, and spewed large amounts of aerosols into high altitudes (~30-60 km) of the atmosphere. The unusual height and loading of the Tonga aerosol layer cause strong interferences in ozone retrievals that are not sufficiently addressed by the standard data quality check in the OMTO3 algorithm, thus requiring special processing to correctly qualify the data. Therefore, from January 11, 2022 through January 28, 2022, OMTO3 has been processed with enhanced flagging criteria to qualify data associated with this extreme event.

Product Description

A 2600 km wide OMI swath contains 60 pixels. Due to optical aberrations and small misalignment between the instrument optic axis with the spacecraft nadir, the pixels on the ground are not symmetrically aligned on the line perpendicular to the orbital plane. However, the latitude and longitude provided with each pixel represent the location of the center of each pixel on the ground to within a fraction of a pixel.

The OMTO3 product is written as an HDF-EOS5 swath file. For a list of tools that read HDF-EOS5 data files, please visit these links:
https://www.earthdata.nasa.gov/esdis/esco/standards-and-practices/hdf-eos5
http://hdfeos.net/software/tool.php

A single OMTO3 file contains information retrieved from each OMI pixel over the sun-lit portion of one Aura orbit. The data are ordered in time. The information provided in these files includes latitude, longitude, solar zenith angle, reflectivity and total column ozone, aerosol index, radiative cloud fraction and radiative optical centroid cloud pressure from OMCLDRR algorithm, and a large number of ancillary parameters to assess data quality. The most important of these parameters is the “QualityFlags” field, which contains the output error flag in its first four bits. Most users should use data with the error flag = 0 (good sample) or 1 (glint contamination corrected) only. Accepting only these flag values now also excludes data at cross-track positions affected by the OMI radiance row anomaly. The row anomaly flag has also been retained in bit 6 of the “Quality Flags” field for the convenience of users who evaluated it there in the previous OMTO3 version. For a complete list of the fields, flags, and their interpretation please read the OMTO3 file specification.

For users not interested in the detailed swath information provided on OMTO3 level 2 dataset, we provide several gridded products. Presently, we grid OMTO3 data in a format similar to that used for TOMS (1˚ × 1˚ latitude/longitude) and it is available as the OMTO3d product. However, to take advantage of the higher spatial resolution of the OMI products we also produce higher resolution gridded products for OMI datasets, including OMTO3e. In addition, we make OMTO3 level 2 data available in a geographically ordered (rather than time-ordered) format (OMTO3G) that can be more easily subsetted and manipulated on-line prior to ordering. Please check the NASA Earth Observation Data website for current information on these products.

Subsets of OMTO3 data over many ground stations and along Aura validation aircraft flight paths are also available through the AVDC website to those investigators who are associated with the various Aura science teams. Michael Yan is the point of contact at the AVDC.

Questions related to the OMTO3 product should be directed to the GES DISC. For questions and comments related to the OMTO3 algorithm and data quality please contact Zachary Fasnacht and Matthew Bandel, with copies to Can Li.

Reference

Ahmad, Z., P.K. Bhartia, N. Krotkov, Spectral properties of backscattered UV radiation in cloudy atmospheres, *J. Geophys. Res.*, 109, D01201, doi:10.1029/2003JD003395, 2004.

Bhartia, P. K., and C. W. Wellemeyer, OMI TOMS-V8 Total O_3 Algorithm, Algorithm Theoretical Baseline Document: OMI Ozone Products, edited by P. K. Bhartia, vol. II, ATBD-OMI-02, version 2.0, 2002. Available at: https://eospso.gsfc.nasa.gov/atbd-category/49.

Vasilkov, A., J. Joiner, R. Spurr, P. K. Bhartia, P. Levelt, and G. Stephens (2008), Evaluation of the OMI cloud pressures derived from rotational Raman scattering by comparisons with other satellite data and radiative transfer simulations, *J. Geophys. Res.*, 113, D15S19, doi:10.1029/2007JD008689.