

# EPIC Tropospheric Column Ozone Version 1.0

Jerald Ziemke (MSU/NASA GSFC) and Natalya Kramarova (NASA GSFC)  
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The Earth Polychromatic Imaging Camera (EPIC) on the DSCOVR spacecraft provides measurements of Earth-reflected radiances from the entire sunlit portion of the Earth. The measurements from four EPIC UV channels are used to reconstruct global distributions of total ozone. The tropospheric ozone columns (TCO) are then derived by subtracting independently measured stratospheric ozone columns from the EPIC total ozone. TCO data product files report gridded synoptic maps of TCO measured over the sunlit portion of the Earth disk on a 1-2 hour basis. Sampling times for these hourly TCO data files are the same as for the EPIC L2 total ozone product. This Version 1.0 of the TCO product is based on Version 3 of the EPIC L1 product and the Version 3 Total Ozone Column Product. The stratospheric columns were derived from the Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) ozone fields (Gelaro et al., 2017). In contrast to the EPIC total ozone maps that are reported at high spatial resolution of  $18 \times 18 \text{ km}^2$  near the center of the image, the TCO maps are spatially averaged over several EPIC pixels and reported on a regular spatial grid ( $1^\circ$  latitude x  $1^\circ$  longitude). Kramarova et al. (2021) provide a detailed description of the EPIC TCO product and its evaluation against independent sonde and satellite measurements. Table 1 lists all of the variables included in the TCO product files. Ozone arrays in the product files are integrated vertical columns in Dobson Units (DU;  $1 \text{ DU} = 2.69 \times 10^{20} \text{ molecules m}^{-2}$ ).

## *Filename Convention*

The TCO product files are formatted HDF EOS5 and represent a Level-4 (L4) product. The filenames have the following naming convention:

”DSCOVR\_EPIC\_L4\_TrO3\_01\_YYYYMMDDHHMMSS\_03.h5”

where “TrO3” means tropospheric column ozone, “01” means that this is version 01 for this product, “YYYYMMDDHHMMSS” is the UTC measurement time with “YYYY” for year (2015-present), “MM” for month (01-12), “DD” for day of the month (1-31), and “HHMMSS” denotes hours-minutes-seconds, and “03” signifies that v3 L1b measurements were used to derive the EPIC total ozone and consequently TCO.

## *Column Weighting Function Adjustment*

There are two TCO gridded arrays in each hourly data file for the user to choose from; one is denoted TroposphericColumnOzone and the other is TroposphericColumnOzoneAdjusted. The latter TCO array includes an adjustment to correct for reduced sensitivity of the EPIC UV measurements in detecting ozone in the low troposphere/boundary layer. The adjustment depends on latitude and season and was derived using simulated tropospheric ozone from the GEOS-Replay model (Strode et al. 2020) constrained by the MERRA-2 meteorology through so-called replay method. Our analysis (Kramarova et al., 2021) indicated that the adjusted TCO array is more accurate and precise.

## ***Flagging Bad Data***

Kramarova et al. (2021) notes that the preferred EPIC total ozone measurements used for scientific study are those where the L2 “AlgorithmFlag” parameter is equal to 1, 101, or 111. In this TCO product we have included only L2 total ozone pixels with these algorithm flag values. A gridded version of the AlgorithmFlag parameter is provided in the TCO product files, as a comparison reference, but it is not needed by the user for applying data quality filtering.

Another parameter in the EPIC L2 total ozone files for filtering questionable data is the “ErrorFlag”. The TCO product files include a gridded version of this ErrorFlag parameter that the user should apply. Only TCO gridded pixels with ErrorFlag value of zero should be used.

TCO measurements at high satellite look angles and/or high solar zenith angles should also be filtered out for analysis. The TCO files include a gridded version of the satellite look angle and the solar zenith angle denoted as “SatelliteLookAngle” and “SolarZenithAngle”, respectively. For scientific applications, users should filter TCO array data and use only pixels with SatelliteLookAngle and SolarZenithAngle  $< 70^\circ$  to avoid retrieval errors near the Earth view edge.

In summary, filtering the TCO arrays is optional, but for scientific analysis we recommend to apply the following two filters:

- (1) filter out all gridded pixels where ErrorFlag  $\neq 0$ ;
- (2) filter out all pixels where SatelliteLookAngle or SolarZenithAngle  $> 70^\circ$ .

## ***Summary of the Derivation of the tropospheric column ozone product***

We provide a short summary of the derivation of EPIC TCO, stratospheric column ozone, and tropopause pressure. To derive EPIC TCO, an independent measure of the stratospheric column ozone is needed. We use MERRA-2 ozone fields (Gelaro et al., 2017) to derive stratospheric ozone columns that are subtracted from EPIC total ozone (TOZ) to obtain TCO. The MERRA-2 data assimilation system ingests Aura OMI v8.5 total ozone and MLS v4.2 stratospheric ozone profiles to produce global synoptic maps of profile ozone from the surface to the top of the atmosphere; for our analyses we use MERRA-2 ozone profiles reported every three hours (0, 3, 6, ..., 21 UTC) at a resolution of  $0.625^\circ$  longitude  $\times$   $0.5^\circ$  latitude. MERRA-2 ozone profiles were integrated vertically from the top of the atmosphere down to tropopause pressure to derive maps of stratospheric column ozone. Tropopause pressure was determined from MERRA-2 re-analyses using standard PV- $\theta$  definition (2.5 PVU and 380K). The resulting maps of stratospheric column ozone at 3-hour intervals from MERRA-2 were then space-time collocated with EPIC footprints and subtracted from the EPIC total ozone, thus producing daily global maps of residual TCO sampled at the precise EPIC pixel times. These measurements of tropospheric ozone were further binned to  $1^\circ$  latitude  $\times$   $1^\circ$  longitude resolution.

## ***References***

Gelaro, R., W. McCarty, M.J. Suárez, R. Todling, A. Molod, L. et al., The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2), *J. Climate*, 30, 5419–5454, <https://doi.org/10.1175/JCLI-D-16-0758.1>, 2017.

Kramarova N. A., J. R. Ziemke, L.-K. Huang, J. R. Herman, K. Wargan, et al., Evaluation of Version 3 total and tropospheric ozone columns from EPIC on DSCOVR for studying regional scale ozone variations, *Front. Rem. Sens.*, in review, 2021.

**Table 1.** List of parameters and data arrays in the EPIC tropospheric ozone hourly product files. The left column lists variable name, the second column lists the variable description and units, and the third column lists the variable data type and dimensions.

<b>Product Variable Name</b>	<b>Description and units</b>	<b>Data Type and Dimensions</b>
NadirLatitude	Nadir latitude in degrees	Real*4 number
NadirLongitude	Nadir longitude in degrees	Real*4 number
Latitude	Center latitude of grid-point in degrees	Real*4 array with 180 elements
Longitude	Center longitude of grid-point in degrees	Real*4 array with 360 elements
TroposphericColumnOzone	Tropospheric column ozone in Dobson Units	Real*4 array with dimensions 360 × 180
TroposphericColumnOzoneAdjusted	Tropospheric column ozone with BL adjustment in Dobson Units	Real*4 array with dimensions 360 × 180
StratosphericColumnOzone	Stratospheric column ozone in Dobson Units	Real*4 array with dimensions 360 × 180
TotalColumnOzone	Total column ozone in Dobson Units	Real*4 array with dimensions 360 × 180
Reflectivity	Reflectivity (no units)	Real*4 array with dimensions 360 × 180
RadiativeCloudFraction	Radiative cloud fraction (no units)	Real*4 array with dimensions 360 × 180
TropopausePressure	Tropopause pressure in units hPa	Real*4 array with dimensions 360 × 180
CWF1	Column weighting function for layer 1 (506.6-1013.3 hPa)	Real*4 array with dimensions 360 × 180
ErrorFlag	Error flag for TCO data	Real*4 array with dimensions 360 × 180
AlgorithmFlag	Algorithm flag for TCO data	Real*4 array with dimensions 360 × 180
SatelliteLookAngle	Satellite Look Angle in degrees	Real*4 array with dimensions 360 × 180
SolarZenithAngle	Solar Zenith Angle in degrees	Real*4 array with dimensions 360 × 180