TOAR-II HEGIFTOM: Description of homogenized TMF Tropospheric Ozone Lidar (TMTOL) time series

This document refers to the ozone profiles obtained from the JPL tropospheric ozone differential absorption lidar located at the Table Mountain Facility, California (Lat. 34.4N; Long. 117.7W; Elev. 2285 m a.s.l.; PI: T. Leblanc), also referred to as "TMTOL". This long-term dataset (historically archived at NDACC) consists of 2-hour-averaged nighttime ozone profiles measured routinely 3 to 4 times per week, totaling an average of 150 profiles per year between 2000 and present. Typical altitudes covered are 3-22 km (extended down to 100 m above ground for the most recent years).

Availability

As of February 2023, the complete homogenized time series (2000-present) in hdf-5 format can be obtained via ftp from the TOAR-II HEGIFTOM ftp server "ftp-me.oma.be", accessible with account name "ozonesondes" and password "OzonFeb2021:", in the subdirectory "Lidar". The 2018-present segment of this dataset is also available in GEOMS-compliant HDF4 format at the NDACC data handling center (the 2000-2017 segment will be uploaded to NDACC shortly, so that the full dataset will also be available at NDACC).

Data field description (HDF5 format)

HDF name	Description	Unit	Dim	Comment
Altitude	Geometric altitude	m (a..s.l.)	1D	Primary independent variable
O3_ND	Ozone number density	mol.m-3	1D	Primary dependent variable
Vertical_resolution	Effective vertical resolution (see ref. 1)	m	1D	NDACC-standardized (see ref. 1)
uO3_ND	Uncertainty components (see ref. 2)	mol.m-3	2D	Total uncertainty is in row 1 Individual contributions are in rows 2-14
u_contributions	Sources of uncertainty components	STRING	1D	The only random component is detection noise (row 2)
u_recommended_treatment	Advise how to use uncertainty components	STRING	1D	Useful for computing Level 3 and 4 datasets
Time_start	Measurement start time	MJD	1D	Same time for all altitudes
Time_end	Measurement end time	MJD	1D	Same time for all altitudes
O3_MR	Ozone Volume mixing ratio	m-3.m-3	1D	Derived from O3_ND, xT_O3MR and xP_O3MR
xT_O3MR	Ancillary temperature	K	1D	Used to derive O3_MR
xP_O3MR	Ancillary pressure	Pa	1D	Used to derive O3_MR
xT_O3MR_source	Source of ancillary temperature	STRING	1D	By default: MERRA-2
xP_O3MR_source	Source of ancillary pressure	STRING	1D	By default: MERRA-2

Table 1: Most essential variables

- Metadata file available at NDACC
- Simultaneous surface ozone measurement reported in HDF5 files since 2018

Description of homogenization procedure

Homogenization is done by using the GLASS Data Processing Algorithm, which follows the NDACC Vertical resolution and Uncertainty Budget Standardization Guidelines provided in refs. 1-3. Dataset was re-analyzed with same version of GLASS (v1). The GLASS data processor can analyze raw lidar signals produced by about 15 different lidar instruments contributing to 3 global networks: NDACC, TOLNet and GRUAN. Besides the TMTOL system, lidars relevant to HEGIFTOM and for which data has already been analyzed by GLASS are: OHP tropospheric ozone lidar, Reunion Island tropospheric ozone lidar, all TOLNet lidars, and Mauna Loa, Table Mountain, Lauder, and Eureka stratospheric ozone lidars. However, the re-analysis of multiple large datasets is time-consuming, and full homogenized datasets currently exist only for the JPL-operated lidars.

Data management

Flagging

- Data cleaning: Visual check and cut-off at bottom and top of profiles, as well as cloud-clearing
- No actual flagging, but cloud-contaminated layers are systematically set to missing values
- Data quality indicators: All given by uncertainty

Uncertainties

- NDACC-standardized: All uncertainty components (random and systematic) are explicitly computed following the BIPM Guide to Uncertainty in Measurements (GUM, see refs 2-3)
- Unaccounted uncertainty sources: Aerosols contamination and receiver misalignment

Traceability

- No lidar instrument is traceable to a reference instrument
- TMTOL instrument initial set up description can be found in ref. 4
- Data processing is traceable to GLASS documentation (refs. 1-2 and ref. 5) and references therein

Internal consistency

- Time series of different instruments are internally consistent if analyzed by GLASS, or if algorithms were validated within a network (true for TOLNet, partly true for NDACC)
- References of intercomparison campaigns of different instruments within the same network? Overall conclusions of such studies: SCOOP Campaign (see ref. 6)
- How much inconsistency is left over after homogenization: Aerosol uncertainty.

External consistency

- References of intercomparison studies between TMTOL and ozonesonde: SCOOP Campaign (ref. 6)
- Overall conclusions: TMTOL instrument within 5% of other lidars and ozonesondes

Data quality indicators

- Dataset used by multiple authors for climatology and trend studies (e.g., refs. 7-9)

- Overall: Total uncertainty ranging from 3% to 10% and higher. Larger uncertainty is found at the very top of the profiles (lower STNR), and occasionally at the very bottom (signal saturation or incomplete telescope/laser overlap).
- Longer integration times reduce random noise and improves quality

Current homogenized sites (expansive datasets):

- JPL-Table Mountain Facility (TMF) TMTOL lidar 1999-present
- JPL-Table Mountain Facility (TMF) StratO3 Lidar TMSOL 2018-present (homogenized)
- Mauna Loa Observatory (MLO) StratO3 Lidar MLSOL 1998-present

Potential/future expansion of homogenized sites:

- Observatoire de Haute-Provence (OHP) Trop.O3 lidar 1990-present
- All five TOLNet lidars : dates TBD
- JPL-Table Mountain Facility (TMF) StratO3 Lidar TMSOL 1988-2017

References:

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- (5) Leblanc, T. (in preparation), Re-analysis of the JPL long-term ozone, temperature, aerosols and water vapor Lidar datasets, ESSD, 2023
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