TOAR-II Intercomparison Guidelines for Observations of Tropospheric Column Ozone and Tropospheric Ozone Profiles

Authored by the HEGIFTOM Focus Working Group, March 3, 2022

Preamble

The assessment of ozone trends in the free troposphere and in the tropospheric column is a major priority of TOAR-II. Different TOAR-II Focus Working Groups (FWG) are directly or indirectly contributing to this activity by evaluating the ozone measurements derived from different techniques, in terms of their internal as well as external consistency, and in terms of their application to ozone budget studies and to the understanding of underlying photochemical and dynamical processes. To improve consistency among those cross-FWG activities such as intercomparisons, which will affect the final TOAR-II trends assessment, we recommend a common approach with regard to: 1) the meteorological datasets used to convert the instrument's natural units and coordinates (e.g. ozone number densities, altitude grids) to units and coordinates common to other techniques (e.g. ozone partial pressures, pressure grids); and 2) defining the upper limit of the tropospheric column used to quantify tropospheric column ozone (TCO).

These recommendations have been discussed at several TOAR-II workshops, and the TOAR-II Steering Committee, along with some members from the related FWGs (Satellite Ozone, HEGIFTOM, ROSTEES, OPT, Chemical Reanalysis, Global and Regional Models) have agreed to distribute the following guidelines.

Use of meteorological datasets for coordinate conversions

We recommend the use of the following two reanalyses as meteorological data sources:

- **ERA-Interim** (https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era-interim) We recommend ERA-Interim because the Satellite Ozone Focus Working Group is using the TCR-2 chemical reanalysis (*Miyazaki et al*., 2020) as a transfer standard, which is itself nudged to ERA-Interim.
- **MERRA-2** (https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/), already commonly used in the ozone retrievals of different instruments

Moreover, within the framework of a sensitivity analysis, the use of both reanalyses provides an opportunity to evaluate the impact of the meteorological field on the ozone retrievals. In this context, we refer to the SPARC Reanalysis Intercomparison Project (S-RIP, *Fujiwara et al*., 2017, https://www.sparc-climate.org/activities/reanalysis-intercomparison/, https://www.sparc-climate.org/sparc-report-no-10/), which evaluated a large number of re-analysis models. Within S-RIP the ERA-Interim and MERRA-2 reanalyses were compared (among others) for various key diagnostics. Recently, *Hoffmann and Spang* (2022) evaluated the tropopause characteristics of the ERA5 and ERA-Interim meteorological reanalyses. They installed a public data repository at Forschungszentrum Jülich (https://datapub.fz-juelich.de/slcs/tropopause/), which provides a wealth of tropopause information. Each daily netCDF file provides geopotential height, pressure, temperature, and water vapor volume mixing ratio for the WMO 1st and 2nd tropopause, the cold point, and the dynamical tropopause, derived for the following four re-analyses:

- NCEP: Jan 2000 - Dec 2020 ; 6-hourly x 2.5° lat x 2.5° lon
- ERA-Interim: Jan 2000 - Aug 2019 ; 6-hourly x 0.75° lat x 0.75° lon
- MERRA-2: Jan 2000 - Dec 2020 ; 3-hourly x 0.5 lat° x 0.625° lon
- ERA5: Jan 2007 - Dec 2020 ; hourly x 0.3° lat x 0.3° lon

Within TOAR-II, the use of common tools (scripts) to convert pressure grids to altitude grids, ozone number densities to ozone partial pressure, etc., is highly supported and TOAR-II will enable the distribution or availability of such tools.

Tropospheric column ozone

To determine **tropospheric column ozone (TCO)** values, either for the full or partial tropospheric column, two different approaches are proposed:

- making use of *fixed pressure levels*:
  - from ground to 150 hPa in the tropics (within 15° of the equator)
  - from ground to 200 hPa in the subtropics (15°-30°)
  - from ground to 300 hPa in the midlatitudes (30°-60°)
  - from ground to 400 hPa in the polar regions (> 60°)
- from ground to the *tropopause*, with the tropopause being the first thermal tropopause (WMO definition*, listed below), determined from the profile data from ERA-Interim or MERRA-2 reanalyses (e.g. *Hoffmann and Spang* (2022), see also above).

Here again, we welcome sensitivity studies between both approaches for e.g. assessing tropospheric ozone trends.

For **comparing tropospheric ozone profiles** between different techniques, we recommended applying the averaging kernels (AKs), e.g. satellite, Umkehr, or FTIR AKs, to smooth the observed ozonesonde, lidar, and reanalysis ozone profiles.

Spatial and temporal representativeness

Streamlining the activities regarding spatial and temporal representativeness of tropospheric ozone measurements within TOAR-II is not planned at the moment. However, as providing representativeness information of various observational measurements with chemical reanalyses is one of the key objectives of the Chemical Reanalysis Focus Working Group, the chairs of this FWG agreed to serve as contact points for related activities.

*WMO tropopause definition: The boundary between the troposphere and the stratosphere, where an abrupt change in lapse rate usually occurs. It is defined as the lowest level at which the lapse rate decreases to 2"C km-1 or less, provided that the average lapse rate between this level and all higher levels within 2 km does not exceed 2°C km^{-1}. Occasionally, a second tropopause may be found if the lapse rate above the first tropopause exceeds 3°C km^{-1}. [International Meteorological Vocabulary (2nd ed.). Geneva: Secretariat of the World Meteorological Organization. 1992. p. 636. ISBN 978-92-63-02182-3]

References

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