Harmonization and evaluation of ground-based instruments for free tropospheric ozone measurements (HEGIFTOM)

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Scope within TOAR-II

Well-established techniques to measure the vertical distribution of ozone in the free troposphere and tropopause region include ozonesondes, UV-photometers onboard commercial & research aircraft, Lidars, Dobson Umkehrs, Brewer Mark IV Umkehrs, and FTIRs. Recently, new ground-based UV-visible spectrometers (e.g. MAX-DOAS, Pandora) and satellite instruments (e.g. OMI, TROPOMI), which are based on remote sensing techniques, play an increasing role in the characterization of tropospheric ozone. TOAR I (Gaudel et al., 2018, Tarasick et al., 2019) showed that besides clear regional differences, the distribution and trends of ozone in the troposphere and tropopause region are not always consistent between different datasets obtained from the different standard ozone observing techniques.

Satellite biases range between -10% and +20% and standard deviations are large: about 10-30%, versus 5-10% for sondes, aircraft instruments, lidar and ground-based FTIR (Tarasick et al., 2019). The ground-based ozone datasets serve an important role as reference data for the satellite measurements. For example, in TOAR II, the Satellite Ozone working group aims to reconcile differences between satellite-based ozone retrievals by applying a common methodology for validating trends, using the long-term ozonesonde record.

The ground-based free tropospheric ozone working group will evaluate and harmonize the tropospheric ozone data obtained from the different observing networks of ground-based instruments, in order to (i) reconcile the differences in ozone distribution and trends between the different ground-based platforms, and (ii) provide other TOAR-II working groups harmonized and evaluated data sets of the vertical ozone distributions, within the data policy requirements of the respective networks, that can be used either for validation studies of satellite retrievals and numerical models or for other scientific studies within TOAR-II (e.g. trends assessment, process studies).

Objectives of the WG

Although tropospheric ozone monitoring has evolved from sporadic measurements at a few locations to extensive, well-calibrated networks with formal international collaboration, as well as global satellite observations, it is not comprehensive (Tarasick et al., 2019). Each method of observation has its inherent advantages and limitations, and the different techniques will continue to complement and support each other. In this context, international cooperation and data sharing will be of paramount importance. However, there is currently a need for a comprehensive intercomparison and homogenization of tropospheric ozone measurement methods and the datasets produced by them. The working group will bring together different networks of ground-based instruments measuring free tropospheric ozone (see Table), not only to strengthen, speed up, and expand existing activities of harmonization of instruments, but also to compare Quality Assurance/Quality Control (QA/QC) procedures and reports, and harmonization efforts between the different networks. Moreover, at dedicated sites or for identical air masses (in case of e.g. ozonesondes and aircraft measurements), the data themselves and their associated uncertainties will be cross-compared between different techniques. Important aspect thereby will be to investigate the spatial representativeness of the ground-based measurements. Hereby, the output of numerical chemistry-climate models or satellite data can be used as an intermediary or "transfer standard" to test how representative the ground-based tropospheric ozone measurements are. The major deliverable will be quality-assessed ozone datasets for which each measurement has an uncertainty and a quality flag. Instrumental bias, bias drifts and representativeness uncertainty will also be characterized, evaluated and documented. The working group will include both well-established techniques and developing strategies for tropospheric ozone retrieval (MAX-DOAS, Pandora, see Table).

Table: Summary of participating ground-based instruments retrieving tropospheric ozone.

Instrument	Time period	Coverage/Network	Groups
Ozonesondes	1965 - present	~55 sites worldwide (WOUDC, NDACC, SHADOZ)	RMI (Belgium), FZJ (Germany), ECC (Canada), NOAA (USA)
MOZAIC/IAGOS	1994 - present	Cruise altitude (10-12 km) & Airports worldwide	CNRS (France)
FTIR	1995 - present	NDACC, 13-15 sites having more than 10 years of data	BIRA (Belgium), NCAR (USA), AEMET (Spain)
Lidar	1990 – present (NDACC)	NDACC (4 sites), TOLNET (5 sites)	LATMOS (France), NASA (USA), UAH (USA)

Dobson Umkehr	1956 - present	WOUDC	NOAA (USA), MeteoSwiss (Switzerland), BoM (Australia), NIWA (New Zealand), OHP (France)
Brewer Mark IV Umkehr		NEUBrew, EUBrewnet	NOAA (USA), Izaña Atmospheric Research Centre, Spain, Aristotle University of Thessaloniki (Greece), MeteoSwiss (Switzerland)
MAX-DOAS	2010 - present	5-10 NDACC and associated sites	BIRA (Belgium)
Pandora	2012 - present	45 official sites at 20200907, Pandonia Global Network (PGN)	NASA (USA), VTU (USA), LuftBlick (Austria)

Expected outcomes

- homogenized time series of tropospheric ozone measured within an observation network, with uncertainty estimates and quality flags included.
- comparison of reference instruments (including their traceability to the primary standard) for the different ground-based networks among each other, in the existing infrastructure (laboratories, simulation chambers) present in the working group
- characterization and eventual correction of instrumental drifts based on cross-comparisons between instruments at sites hosting different techniques or between instruments measuring identical air masses.
- new tropospheric ozone datasets from existing UV-Vis instrument networks
- in collaboration with other working groups: assessment of the tropospheric ozone distribution and trends of tropospheric ozone, including their spatial representativeness.

Proposed timeline

Nov.-Dec. 2020: (i) workplan + timeline & (ii) solicit new participations in the working group

YEAR#01=2021 (M01-M12): Internal consistency within each network+ Preparation of Year#02

• Feb. 2021: Kick-Off Meeting

• April 2021: Inventory of operation procedures, practices, data correction algorithms, and uncertainty estimation principles that are presently in use at the different sites/instruments within each network

• June 2021: Concept (strategy) for cross intercomparison among different networks (incl. inventory of sites with co-located techniques and identification of identical air masses for in-situ measurements) >>>>> HEGIFTOM Meeting

- Dec. 2021: harmonized and documented datasets, with uncertainty estimates, as input of the cross-comparison between different ground-based techniques and for the satellite ozone working group.

YEAR#02=2022 (M13-M24): External consistency among the networks through intercomparisons

- cross intercomparison among different networks (ground-based and satellite)
- analysis of the spatial representativeness of the ground-based measurements with the help of models and satellite retrievals
- characterization and evaluation of instrumental drifts among the different datasets.

YEAR#03=2023 (M25-M33): Preparation publication(s) and exploitation of data sets with other TOAR-II WG's

Statement

The WG leads and members are aware that participation to this WG is on a voluntary basis and that no funding is provided by TOAR-II. The working group would highly welcome new members and their ideas.