Trends in tropospheric ozone derived from homogenized ground-based and in-situ datasets within TOAR-II

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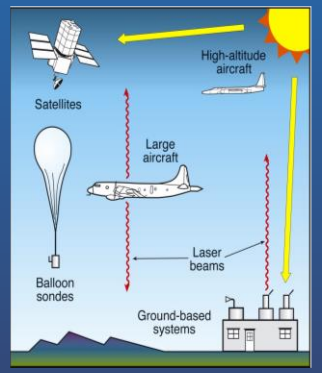


http://hegiftom.meteo.be/

Introduction to TOAR-II Focus Working Group: HEGIFTOM

Harmonization and Evaluation of Ground-based Instruments for Free Tropospheric Ozone Measurements, *chairs: Herman Smit & Roeland Van Malderen*

Key Objective:
Evaluation and harmonization of the different free tropospheric ozone profiling datasets of the established measuring platforms (in-service aircraft, ozonesondes, Brewer/Dobson Umkehr, FTIR, Lidar).

IAGOS


Ozonesondes


Brewer/Dobson Umkehr

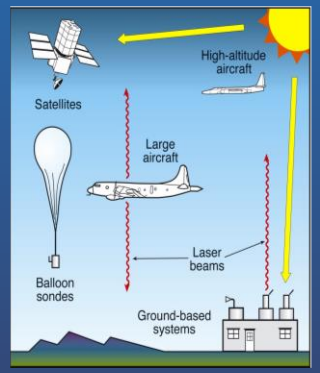

FTIR


Lidar


MAX-DOAS & Pandora

Major Deliverable:
Quality assessed ozone data sets, whereby each measurement gets also an ***uncertainty*** and a ***quality flag***. Thereby, ***representativeness*** and ***instrumental drifts*** will be characterized and evaluated.

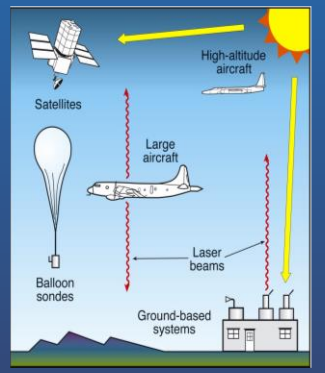
Including:
Testing ozone retrievals from new remote sensing techniques (MAX-DOAS, Pandora) against the established techniques.



http://hegiftom.meteo.be/datasets

Outline

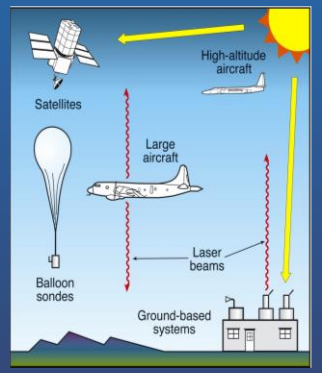
- Homogenization and internal consistency
- External consistency: intercomparisons
- Tropospheric ozone column trend estimates
- Outlook



Homogenized datasets and internal consistency

Achievements and updates:

- **IAGOS**:
  - internal consistency paper published in AMT (Blot et al., 2021, https://doi.org/10.5194/amt-14-3935-2021),
  - simulation chamber comparison of IAGOS (CORE & CARIBIC) UV-photometer and reference photometer for ozonesondes → *see previous talk by Herman Smit*
- **Lidar**: TMF data has been updated with new data processor, OHP will follow
- **FTIR:** flagging applied to the NDACC data
- **Brewer/Dobson Umkehr**:
  - 5 Dobson Umkehr sites have been homogenized (Petropavlovskikh et al., https://doi.org/10.5194/amt-15-1849-2022), 1 to go.
  - Updated uncertainty estimation of the retrievals.
- **ozonesondes**:
  - 12 more sites homogenized, e.g. OHP: Ancellet et al., https://doi.org/10.5194/amt-15-3105-2022 (10-15/55 remaining)
  - WMO-GAW report on Ozonesonde Measurement Principles and Best Operational Practices (https://library.wmo.int/doc_num.php?explnum_id=10884)



Homogenized datasets

Deliverable: Homogenized free tropospheric ozone profile data, described at HEGIFTOM website, with same template for each dataset:

Availability

location (ftp, data archive, website, doi, e-mail address contact person, etc.).

Data field description

Measured data fields (and their units), incl. auxiliary data fields, available metadata. Data format.

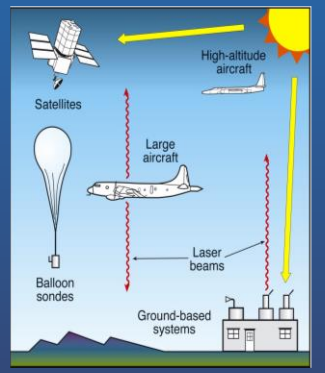
Description of homogenization procedure

short description of the steps taken to make the dataset (more) homogeneous within the network

Data management

- *Flagging*
- *Uncertainties*
- *Traceability*
- *Internal consistency*
- *External consistency*
- *Data quality indicators*
- *List of homogenized sites (name, geographical location, period of observations)*

https://hegiftom.meteo.be/datasets



Homogenized datasets

TOAR-II HEGIFTOM: Description of homogenized IAGOS free-tropospheric ozone time series

Version	Author	Affiliation	Contact	Date
v0	Romain Blot	CNRS, LAERO, UT3	blot.romain@aero.obs-mip.fr	21/12/2021
v1	Romain Blot	CNRS, LAERO, UT3	blot.romain@aero.obs-mip.fr	06/07/2022

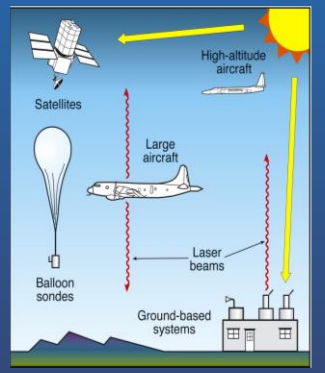
Data management plan

The IAGOS Data Management Plan (DMP) document is publicly available here: https://iagos.aeris-data.fr/documents/. The purpose of this document is to describe the data management life-cycle, and the plans for the data collected, processed, generated and published. The goal of the DMP is to describe the present situation and the operational IAGOS Data Centre. Furthermore, the DMP also describes the technical solutions agreed, that are currently under implementation, and outline the strategy and development needed towards making IAGOS data FAIR.TheDMP is a living document that will be updated regularly. The goal is to make the DMP accessible for all stakeholders (repository operators, funders, researchers, publishers, infrastructure providers etc.).

Data availability

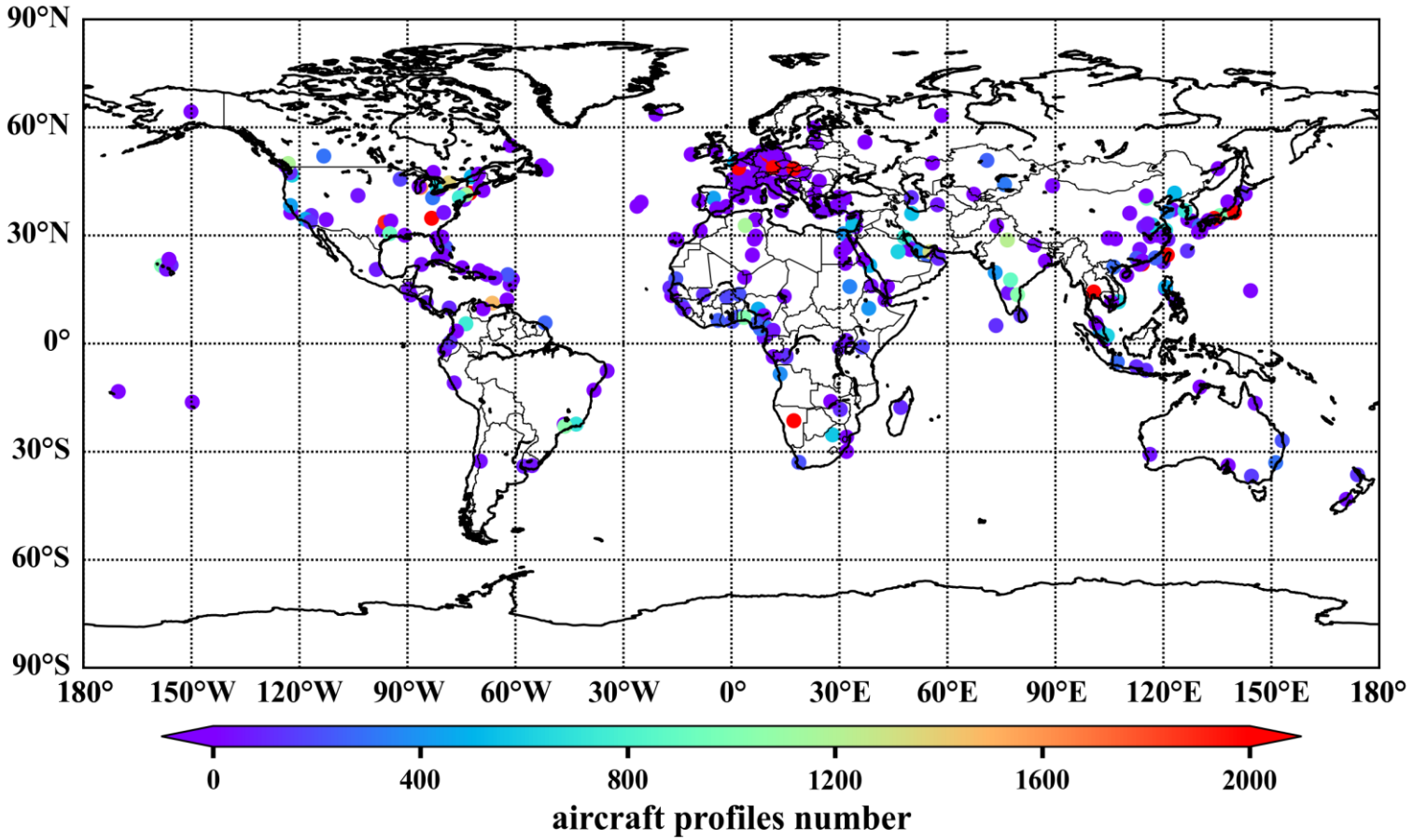
The IAGOS ozone time series are in open access using the IAGOS data portal available at http://www.iagos.org/. A registration is mandatory in order to grant access to the data-set (https://iagos.aeris-data.fr/registration/#). This is not a way of restricting access. This is asked to

https://hegiftom.meteo.be/datasets/iagos



Homogenized datasets: IAGOS

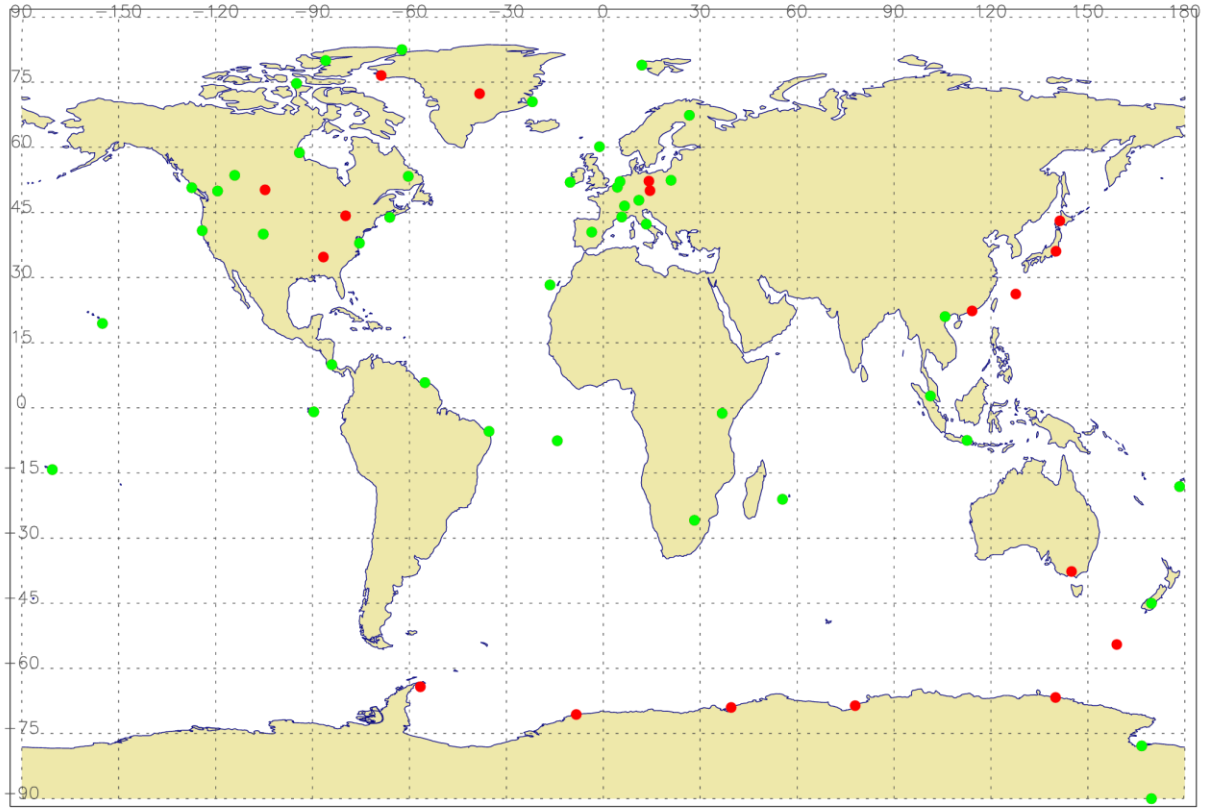
Map of airports

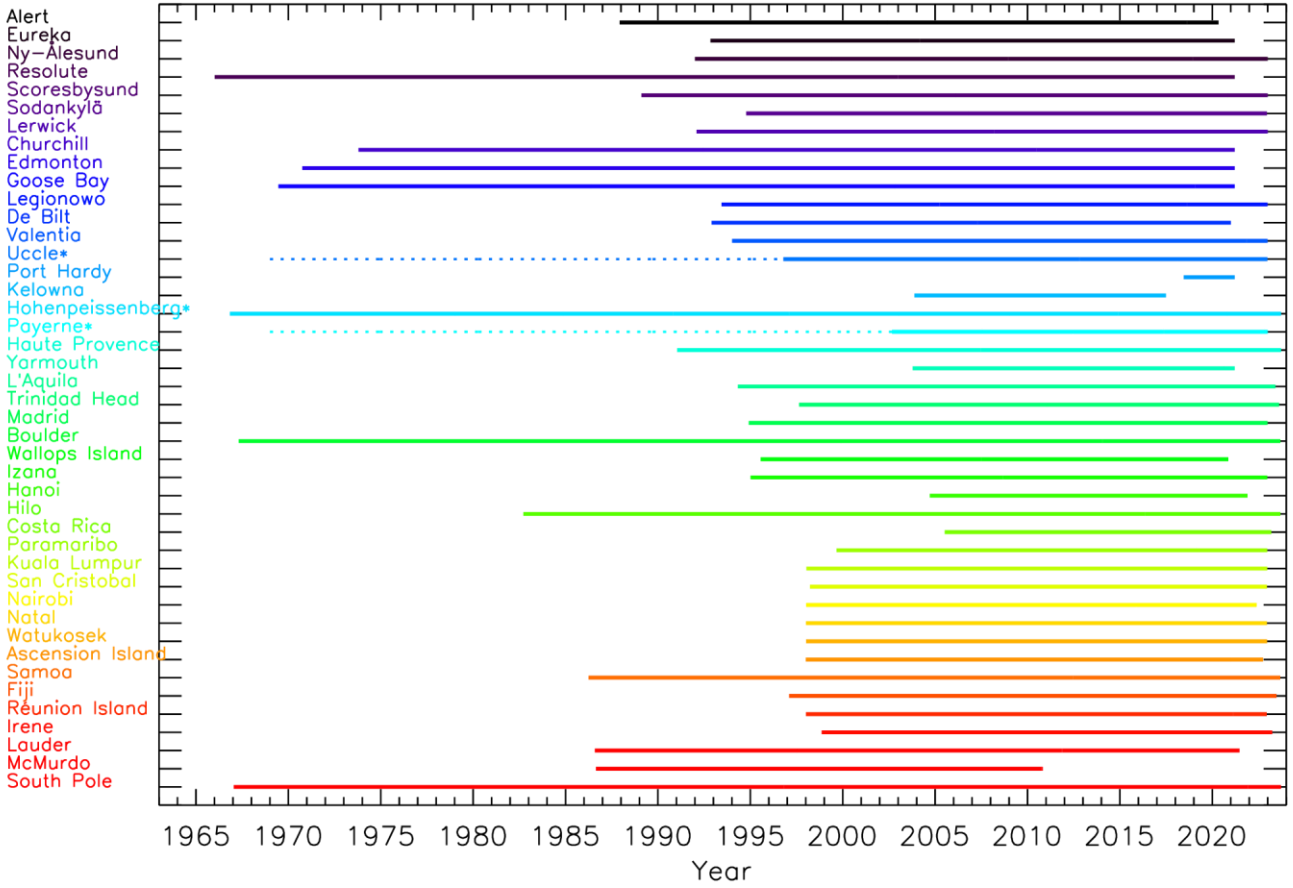


https://hegiftom.meteo.be/datasets/iagos

1994/08 to 2021/03
310 stations
122574 profiles

Homogenized datasets: Ozonesondes

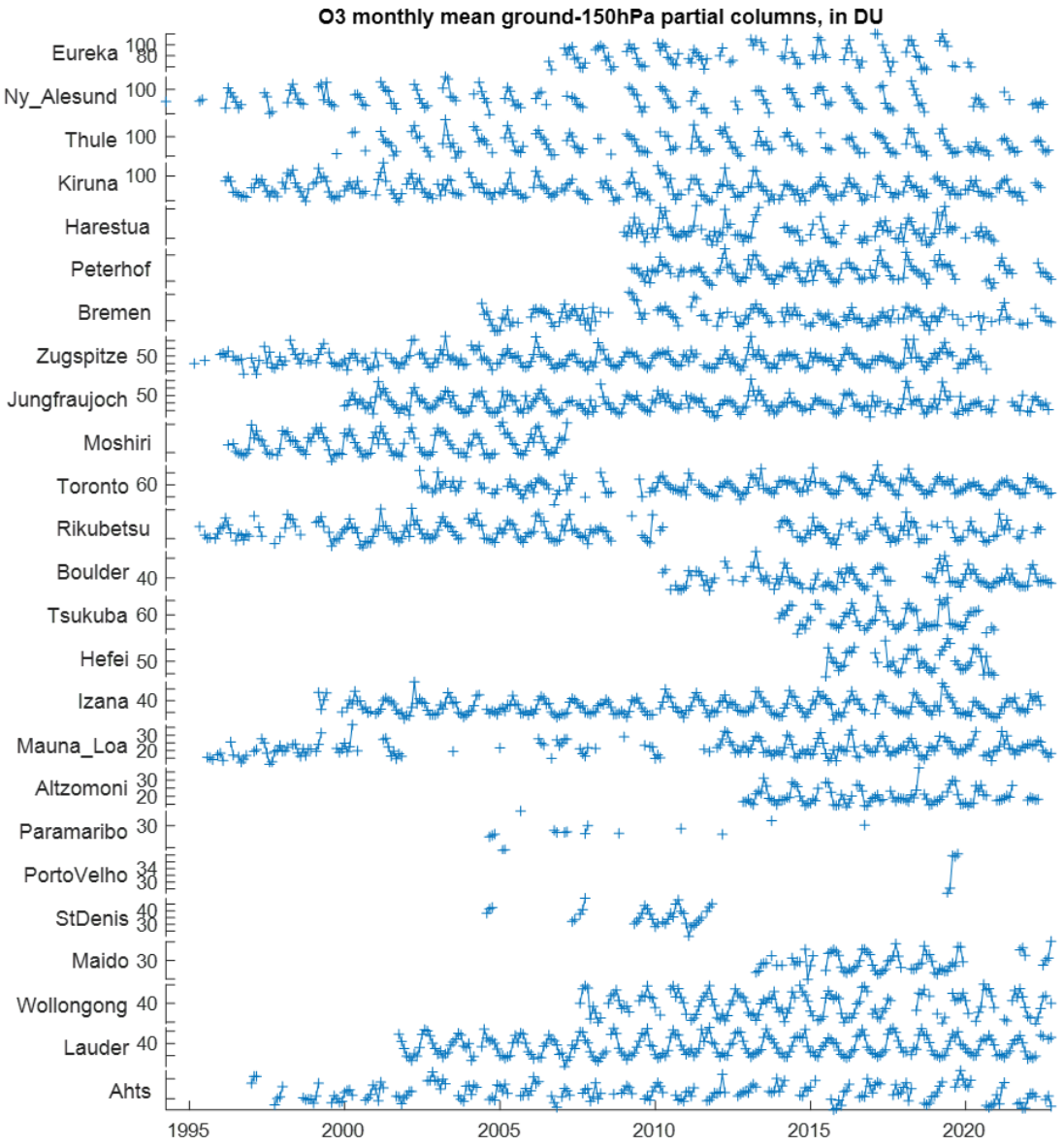




- 43 sites (green dots) with homogenized ozone profile data
- profile data available at ftp-server

https://hegiftom.meteo.be/datasets/ozonesondes

Homogenized datasets: FTIR



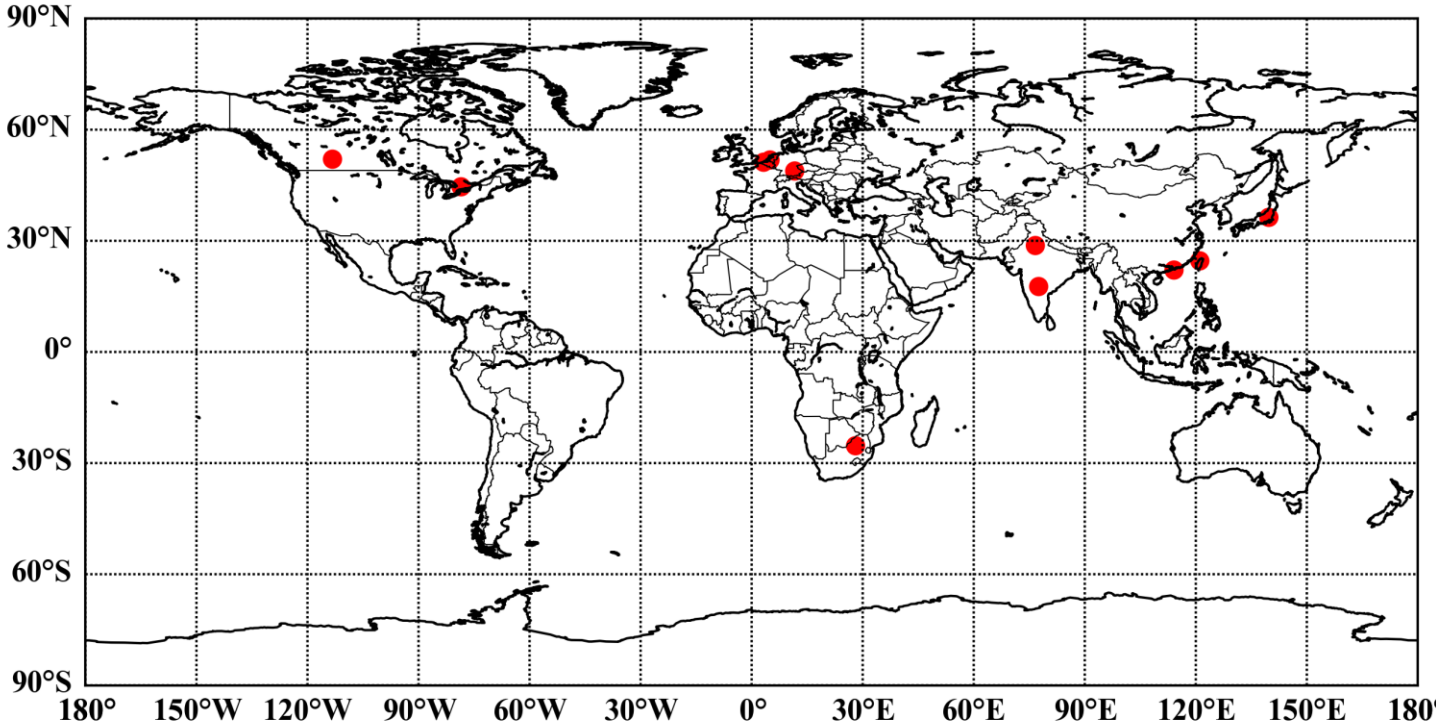
- 25 sites (22 active in O_3) providing O_3 data. See NDACC Infrared WG: https://www2.acom.ucar.edu/irwg
- oldest date back to the mid 90s, most since mid 2000s
- those sites also provide CO/HCHO

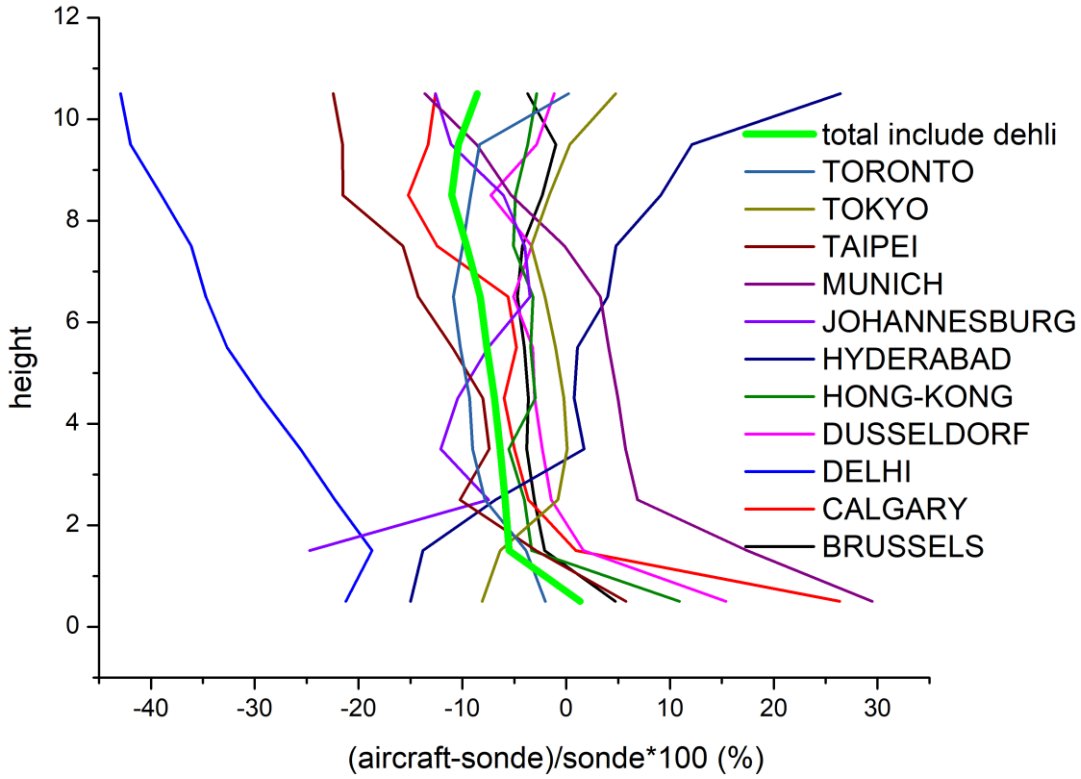
https://hegiftom.meteo.be/datasets/ftir

External Consistency: intercomparisons

- **Deliverable:** TOAR-II Intercomparison Guidelines for Observations of Tropospheric Column Ozone and Tropospheric Ozone Profiles (https://igacproject.org/sites/default/files/2022-03/TOAR-II_Guidelines_for_TCO_and_Profile_Intercomparisons.pdf)

IAGOS vs. sondes at 11 stations → *see talk by Wang, Liu, Tarasick et al. (given by me) tomorrow at 17h*

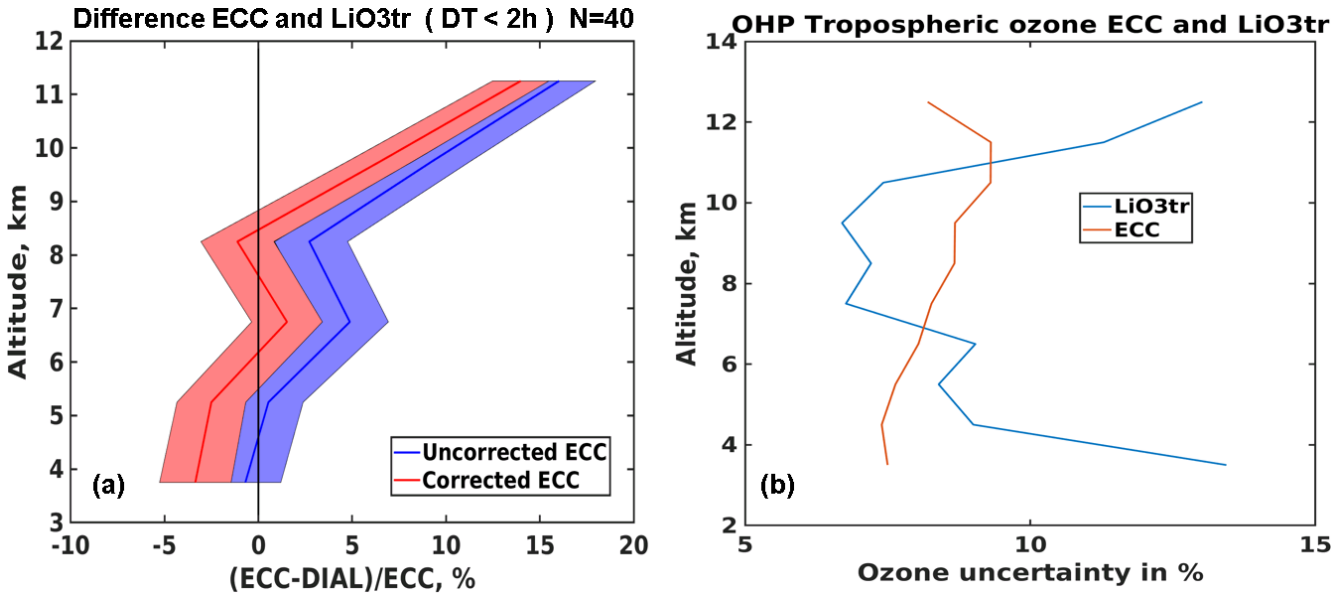




External Consistency: intercomparisons

Intercomparisons: comparison of (tropospheric) ozone retrievals from different ground-based instruments at dedicated sites

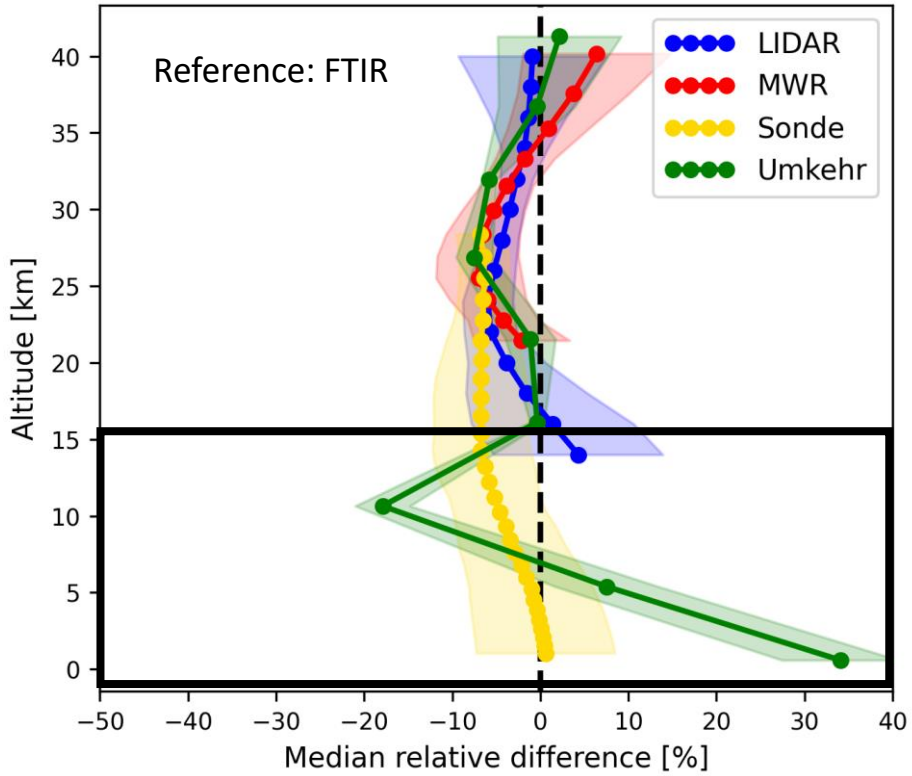
OHP (France)



better agreement between **corrected** ozonesondes and tropospheric lidar at altitudes where instrument uncertainties are minimal!

Ancellet et al., AMT, 2022

Lauder (New Zealand)



Björklund et al., submitted to AMT

Tropospheric ozone column trend estimates

Starting point:

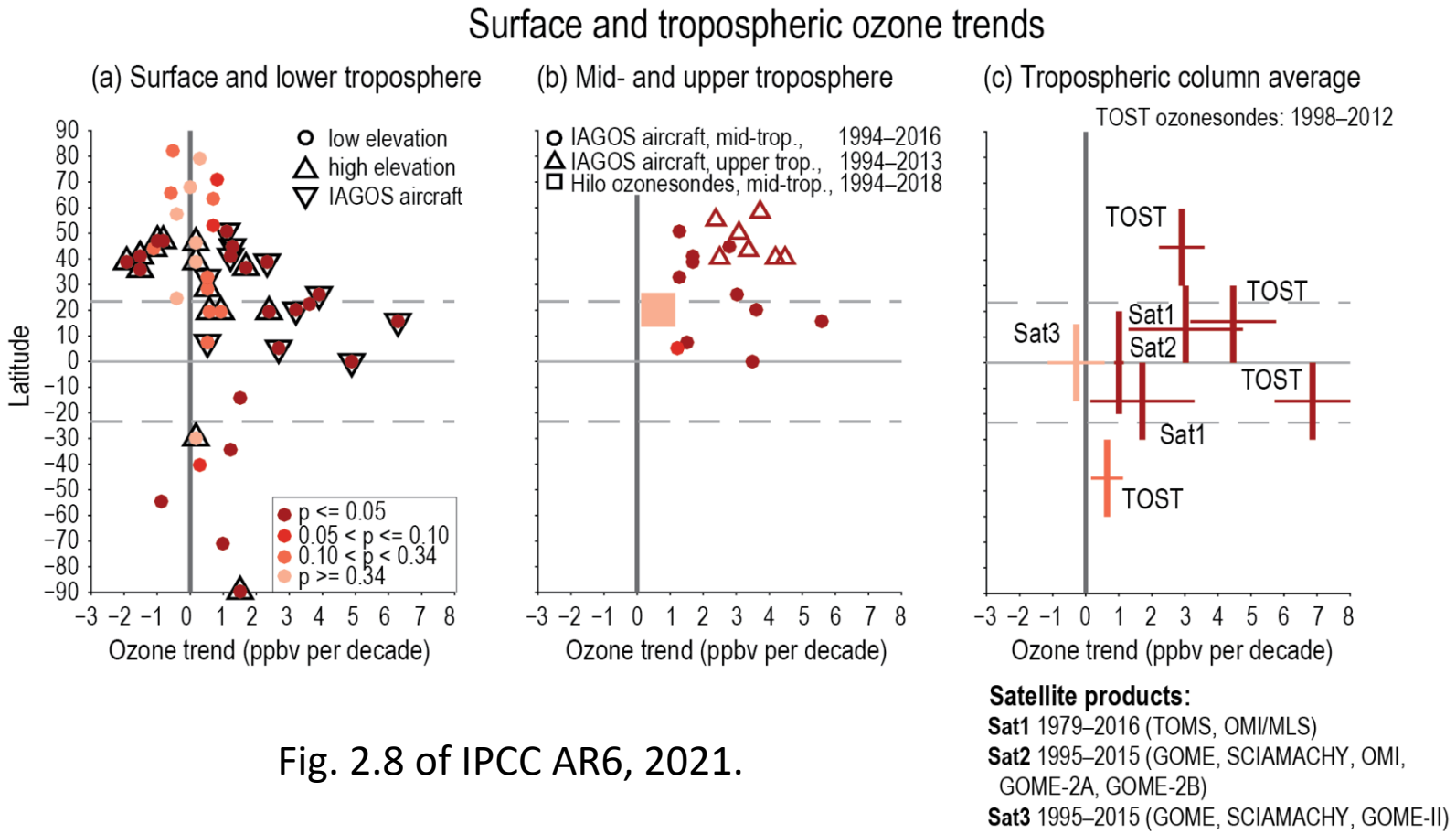


Fig. 2.8 of IPCC AR6, 2021.

- for **individual** HEGIFTOM sites (ozonesondes, IAGOS, FTIR, Lidar, Umkehr)
- different (partial) tropospheric ozone column metrics
- consistency in used trend estimation tools (QR vs. MLR)
- consistency in time ranges (e.g. 2000-2002 till 2019-…)
- consistency in units (ppbv/dec vs. DU/dec)
- = **starting** figures
- = **MINIMAL** figures

Tropospheric ozone column trend estimates

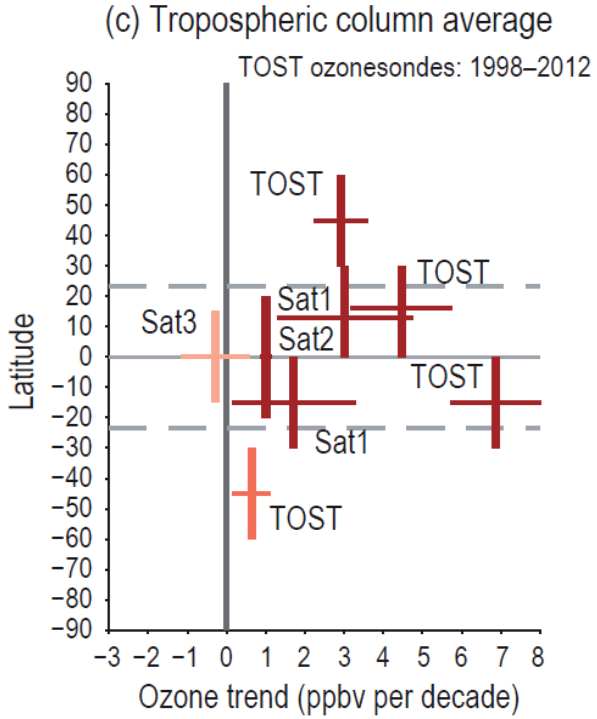
- Different (partial) tropospheric ozone column metrics

1. P > P_TP (WMO)
2. P > P (lat) (e.g. 150 hPa @ tropics, 400 hPa in polar regions)
3. P > 300 hPa
4. FT: 4 < h < 8 km **AND** 700 hPa > P > 300 hPa
5. LT: h < 4 km **AND** P > 700 hPa
6. BL: h < 2 km
7. Umkehr/FTIR kernel weighted to others
8. 1, 2 & 3 + added with CAMS/MERRA2 for UT (IAGOS) and BL (Lidar)

} the 2 recommended TOAR-II tropospheric ozone column definitions

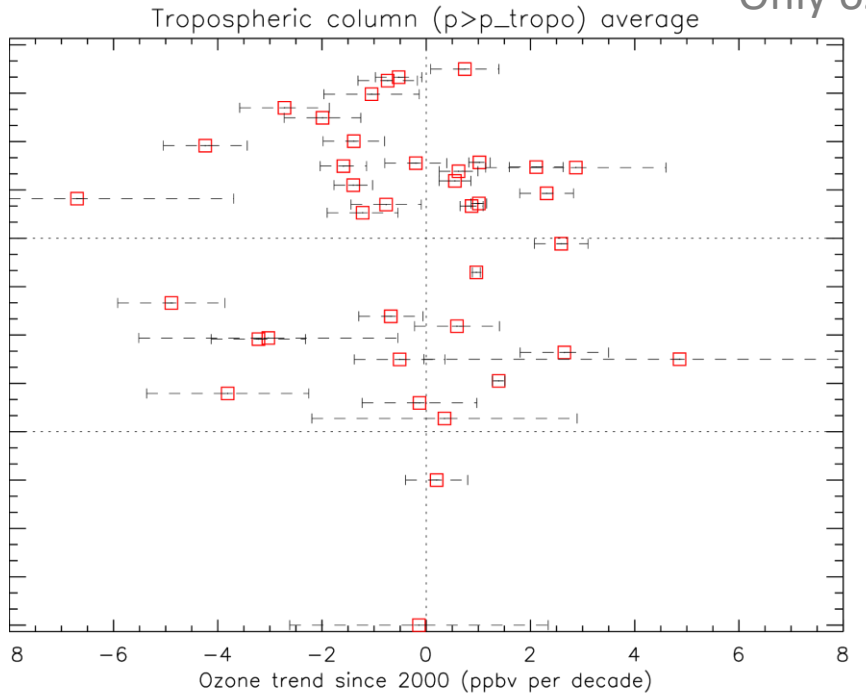
- those (partial) tropospheric ozone columns have been calculated for all sites/techniques, if feasible

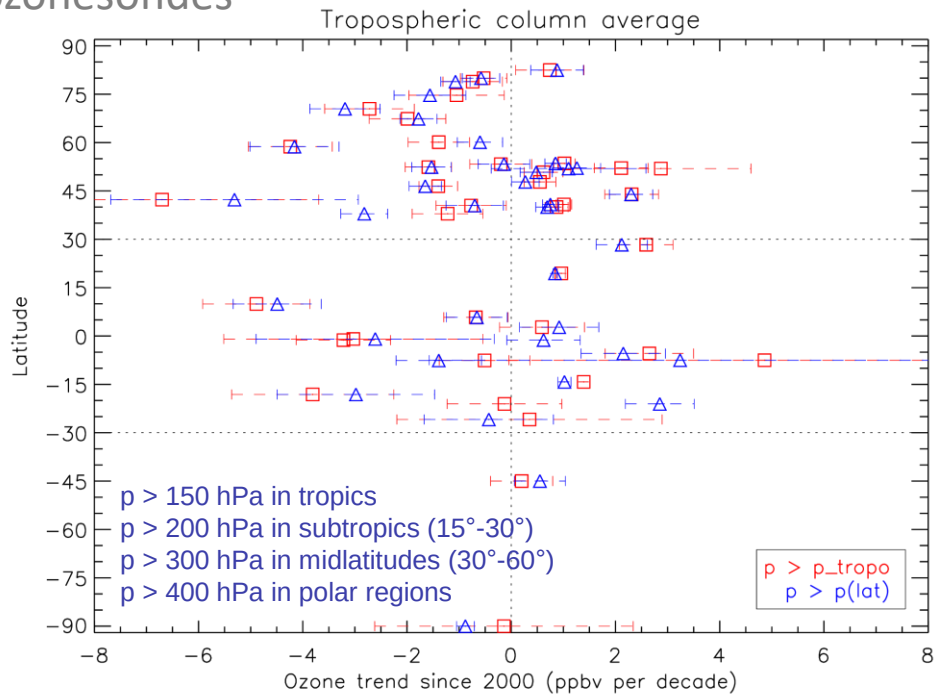
Tropospheric ozone column trend estimates



Satellite products:
Sat1 1979–2016 (TOMS, OMI/MLS)
Sat2 1995–2015 (GOME, SCIAMACHY, OMI, GOME-2A, GOME-2B)
Sat3 1995–2015 (GOME, SCIAMACHY, GOME-II)

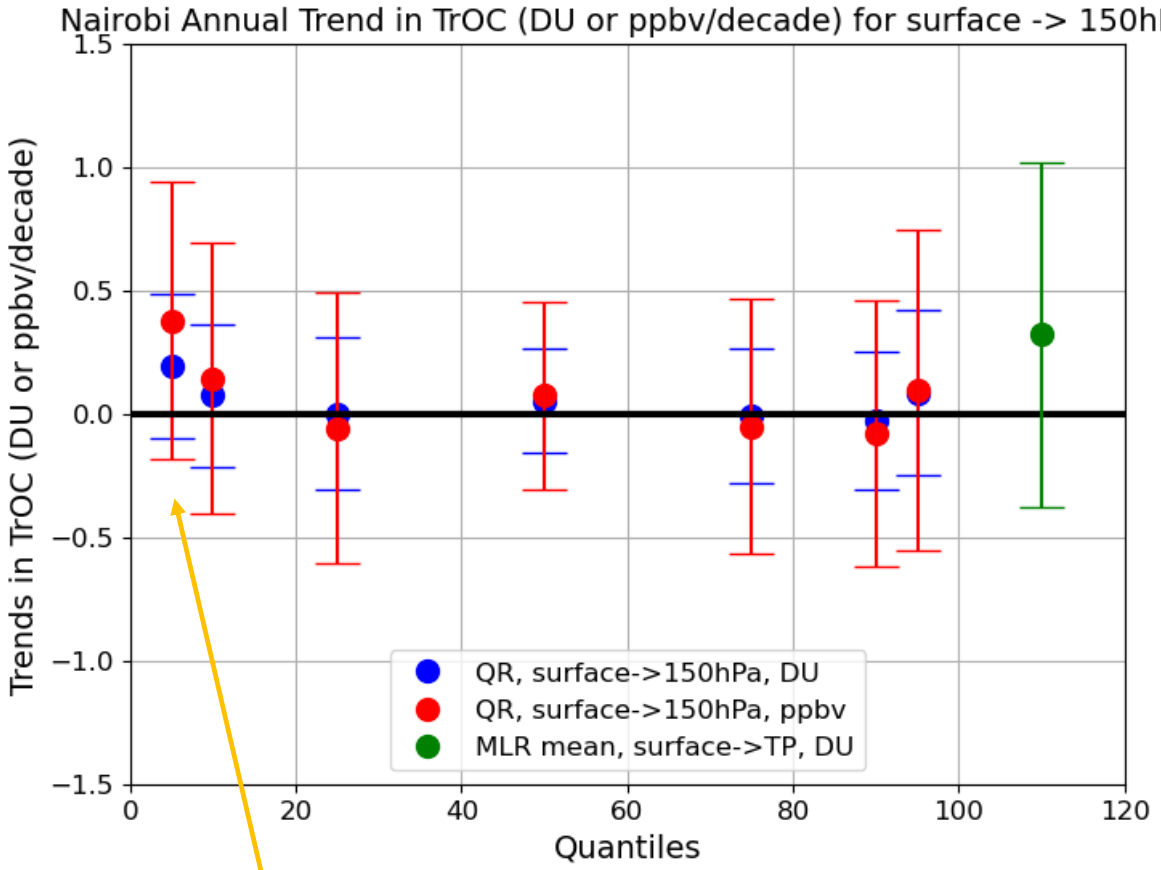
Only ozonesondes





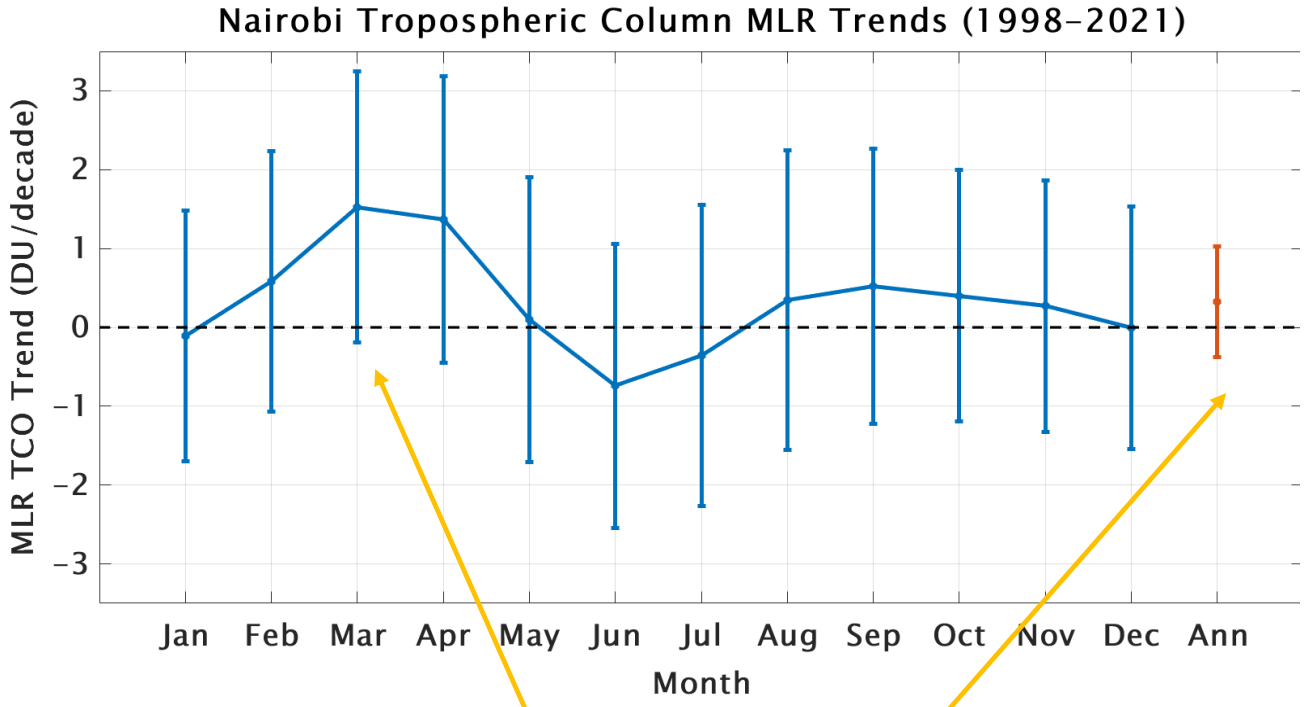
- simple linear regression trend estimation (just for illustration!)
- different metrics = different trends for bulk of stations!
- not only function of latitude!
- much more analysis (and tropospheric ozone column data validation) needed!

Tropospheric ozone column trend estimates



largest trend at lowest O_3

Nairobi ozonesondes



Small annual Nairobi mean trend masks larger Spring trend when O_3 has its annual minimum

➔ different trend estimation tools provide complementary information!

Outlook

- Homogenized profile data from ground-based instruments described/ available at HEGIFTOM website
- **Coming soon:** time series of (partial) tropospheric ozone columns from all instruments
- intercomparison studies in the pipeline + more are needed!
- study the **spatial and temporal representativeness** of ground-based free tropospheric measurements, in collaboration with TOAR-II chemical reanalysis focus working group
- Tropospheric ozone trends from ground-based instruments will be provided for the TOAR-II Climate Assessment
- more information: http://hegiftom.meteo.be