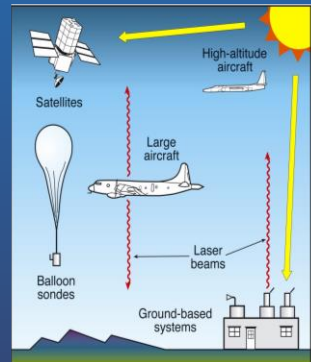


# Homogenized ground-based and profile ozone datasets from the TOAR-II/HEGIFTOM project: methods and station trends

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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

### 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).

### 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.



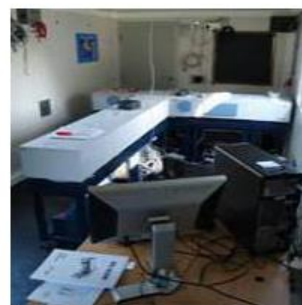
IAGOS



Ozonesondes



Brewer/Dobson Umkehr



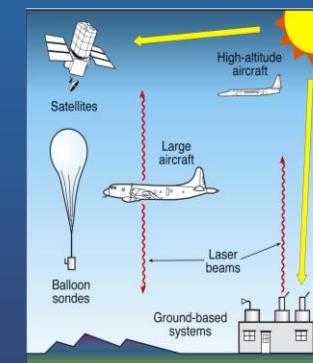
FTIR



Lidar



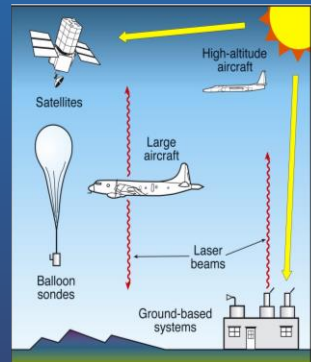
MAX-DOAS & Pandora



<http://hegiftom.meteo.be/datasets>

# Outline

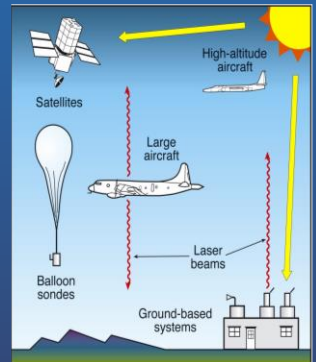
- Homogenization and internal consistency
- External consistency: intercomparisons
- Tropospheric ozone column trend estimates
- Outlook



# Homogenized datasets and internal consistency

## Achievements and updates:

- **IAGOS:**
  - internal consistency paper published in AMT (Blot et al., <https://doi.org/10.5194/amt-14-3935-2021>),
  - simulation chamber comparison of IAGOS-CORE UV-photometer and reference photometer for ozonesondes
- **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 (Petrovavlovskikh 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](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

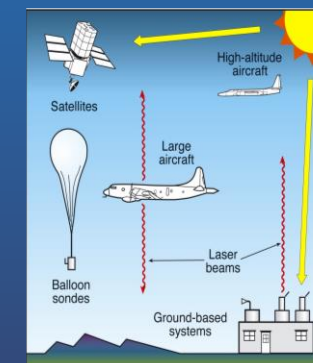
## Description of homogenization procedure

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)*

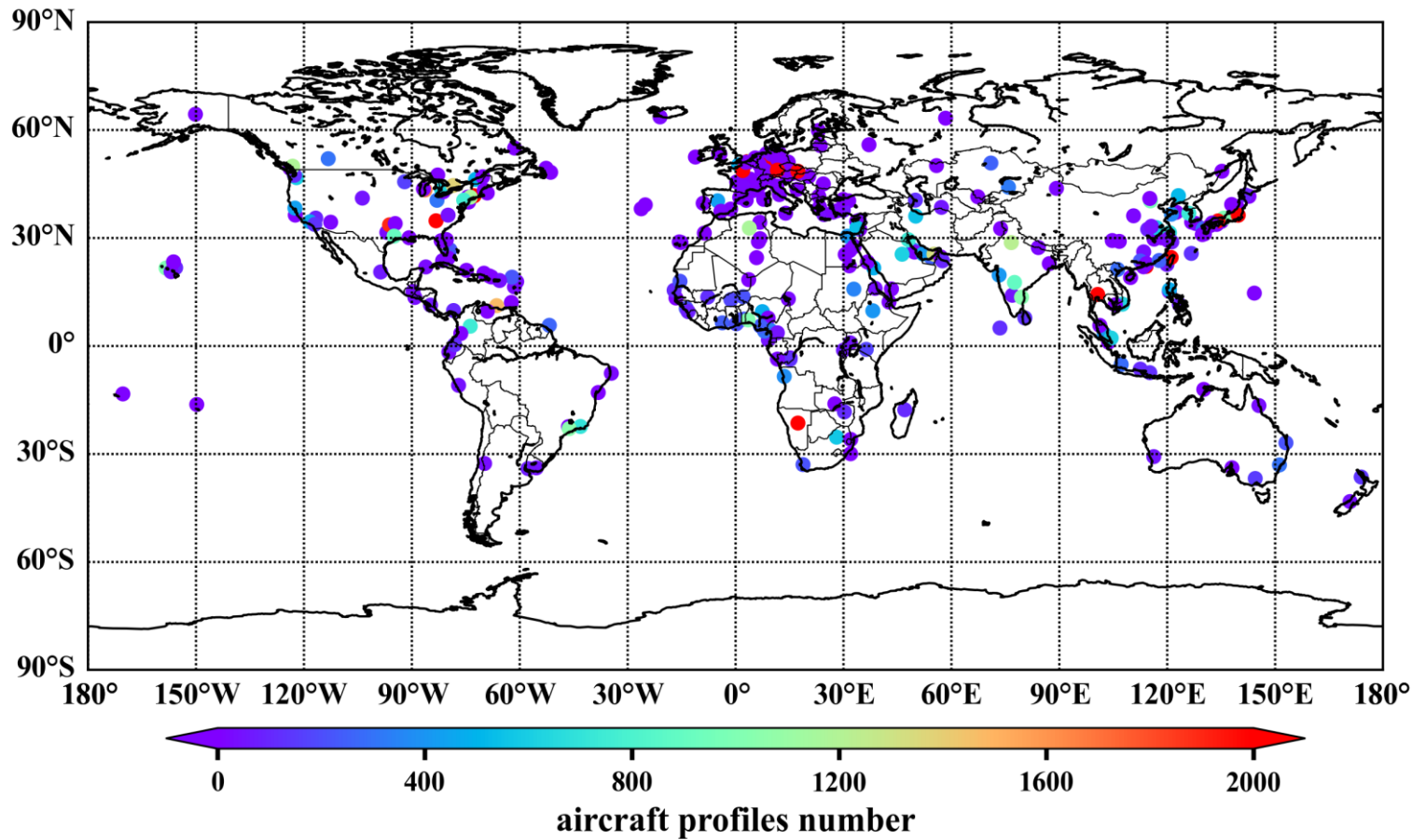
<https://hegiftom.meteo.be/datasets>





# Homogenized datasets: IAGOS

## Map of airports

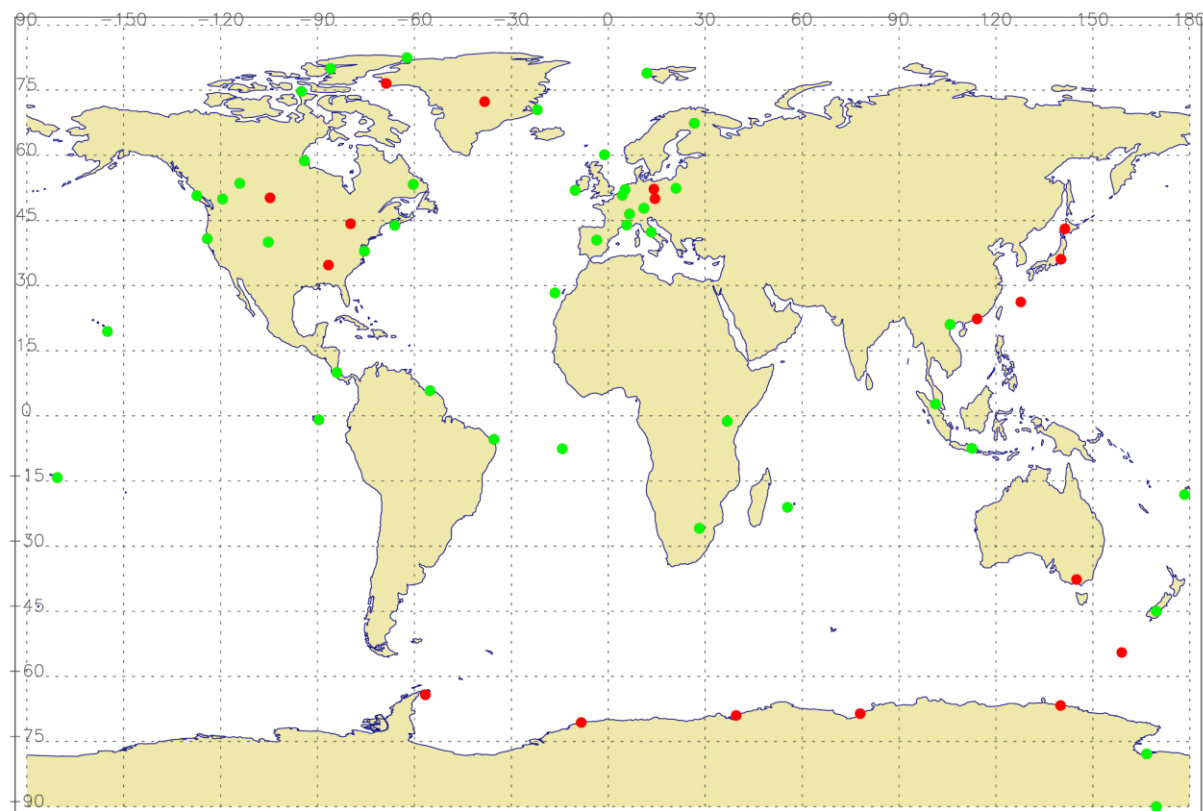


**1994/08 to 2021/03**  
**310 stations**  
**122574 profiles**

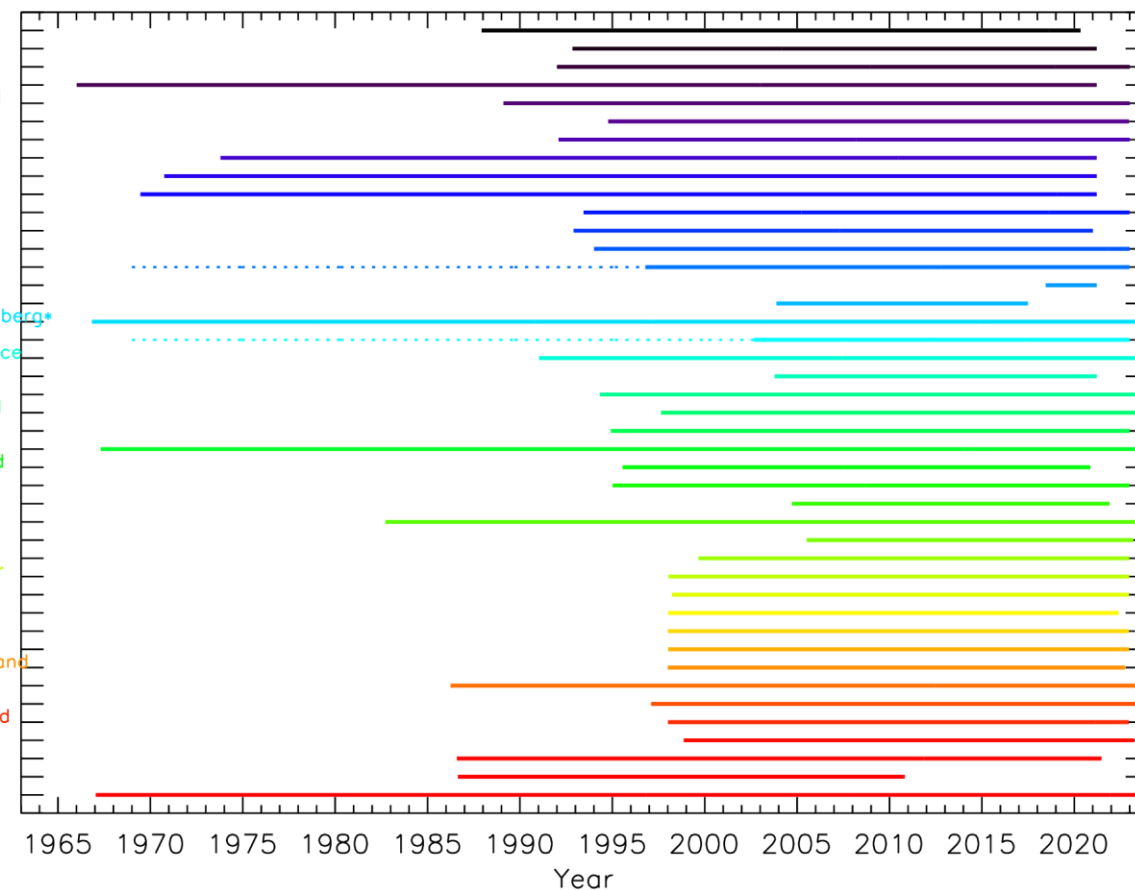


<https://hegiftom.meteo.be/datasets/iagos>  
<http://iagos-data.fr/#TimeseriesPlace>

# Homogenized datasets: Ozonesondes



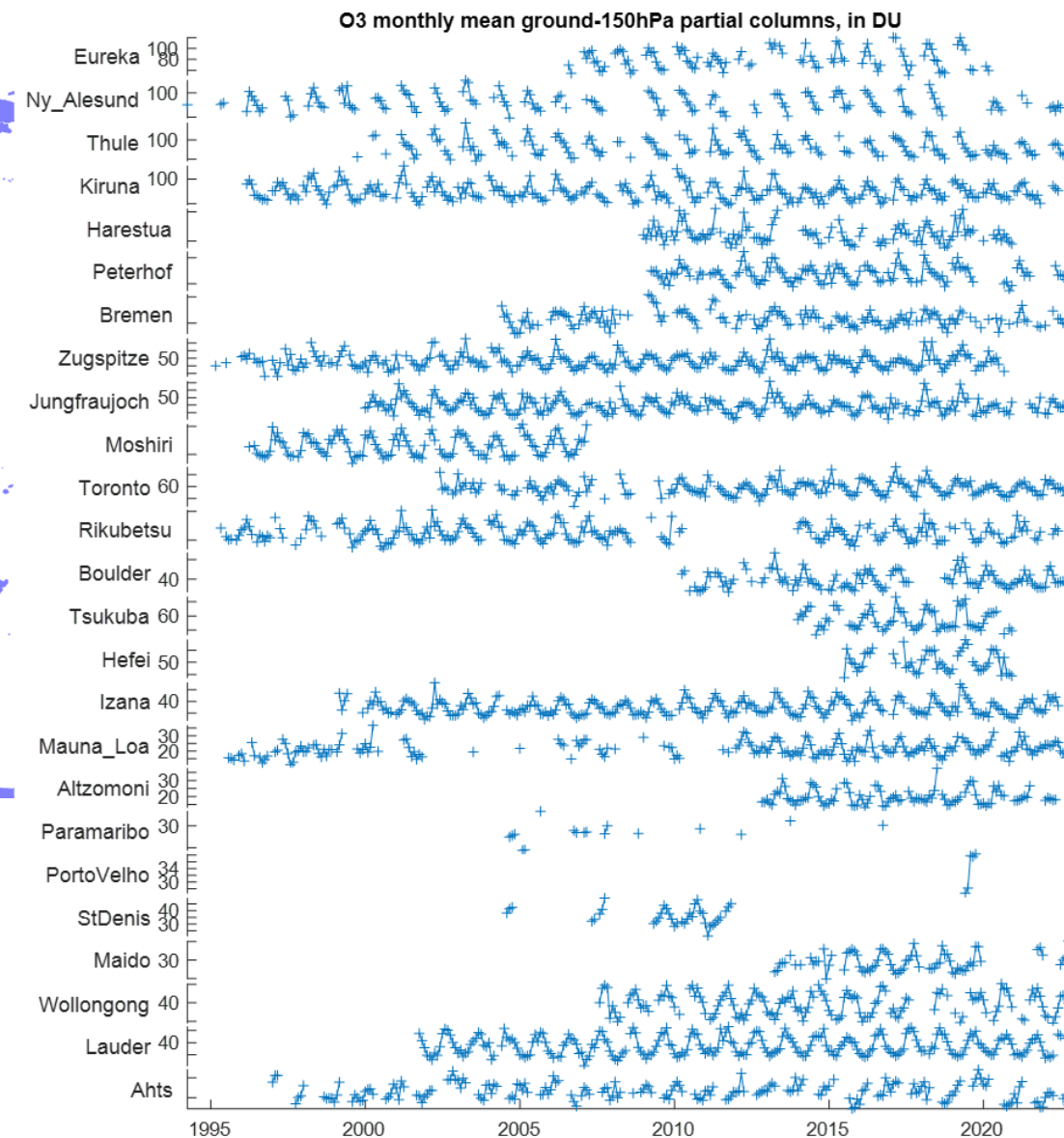
Alert  
Eureka  
Ny-Ålesund  
Resolute  
Scoresbysund  
Sodankylä  
Lerwick  
Churchill  
Edmonton  
Goose Bay  
Legionowo  
De Bilt  
Valentia  
Uccle\*  
Port Hardy  
Kelowna  
Hohenpeissenberg\*  
Payerne\*  
Haute Provence  
Yarmouth  
L'Aquila  
Trinidad Head  
Madrid  
Boulder  
Wallops Island  
Izana  
Hanoi  
Hilo  
Costa Rica  
Paramaribo  
Kuala Lumpur  
San Cristobal  
Nairobi  
Natal  
Watuoksek  
Ascension Island  
Samoa  
Fiji  
Réunion Island  
Irene  
Lauder  
McMurdo  
South Pole



- 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<sub>3</sub>) providing O<sub>3</sub> 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

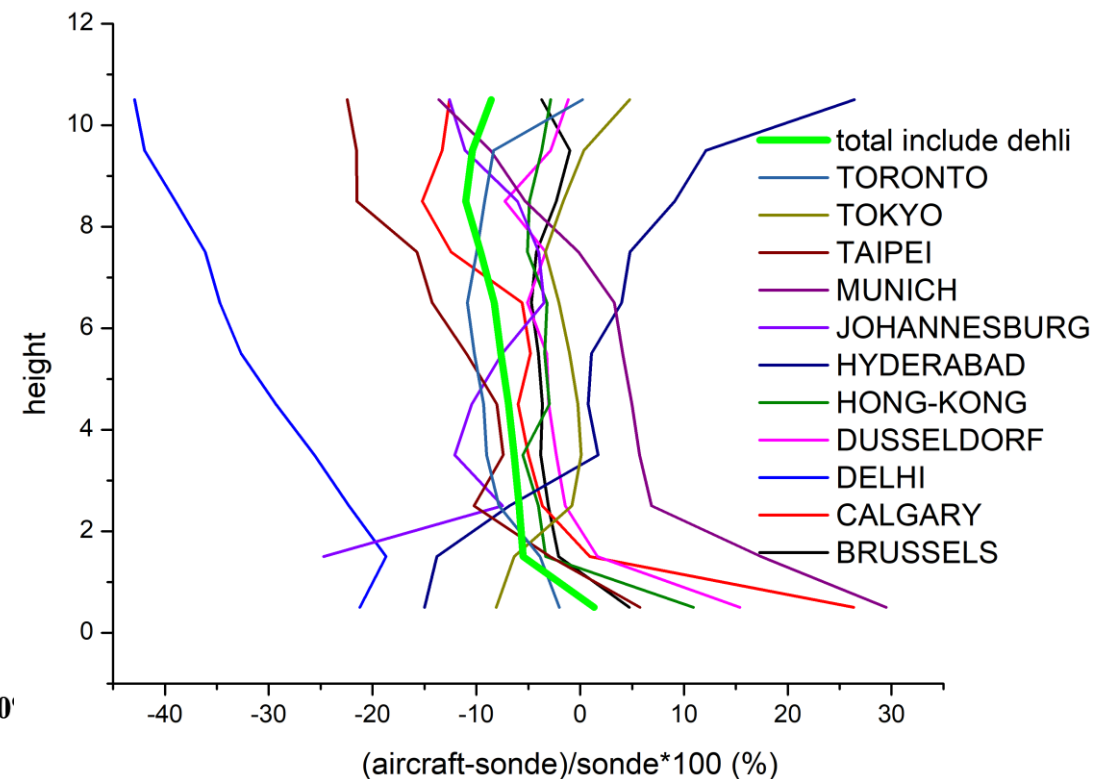
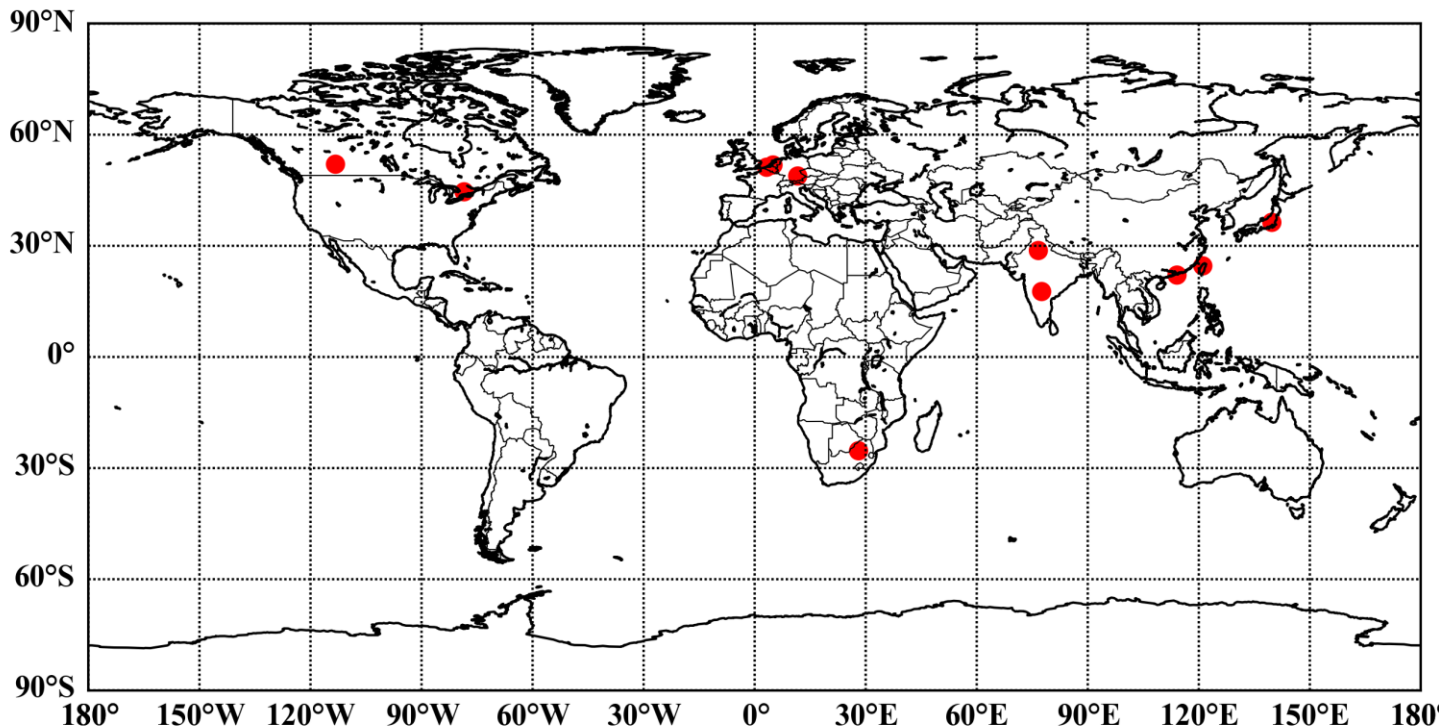
<https://hegiftom.meteo.be/datasets/ftir>



# 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](https://igacproject.org/sites/default/files/2022-03/TOAR-II_Guidelines_for_TCO_and_Profile_Intercomparisons.pdf))

## IAGOS vs. sondes at 11 stations

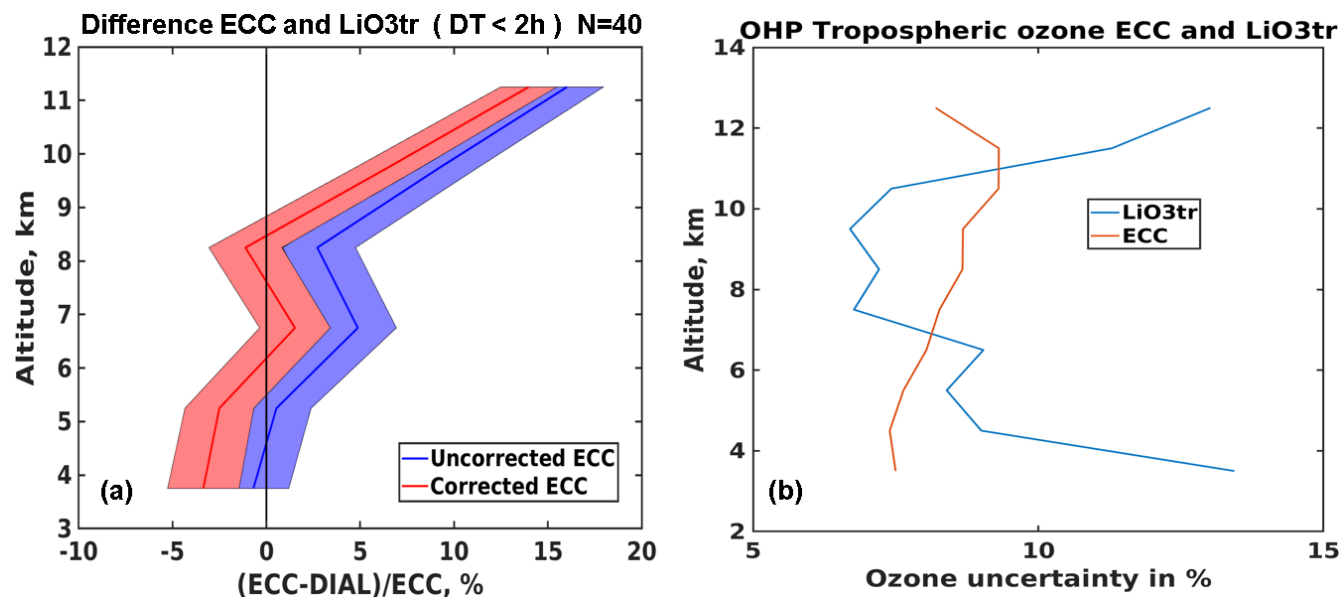


Wang & Tarasick, in preparation

# External Consistency: intercomparisons

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

OHP (France)



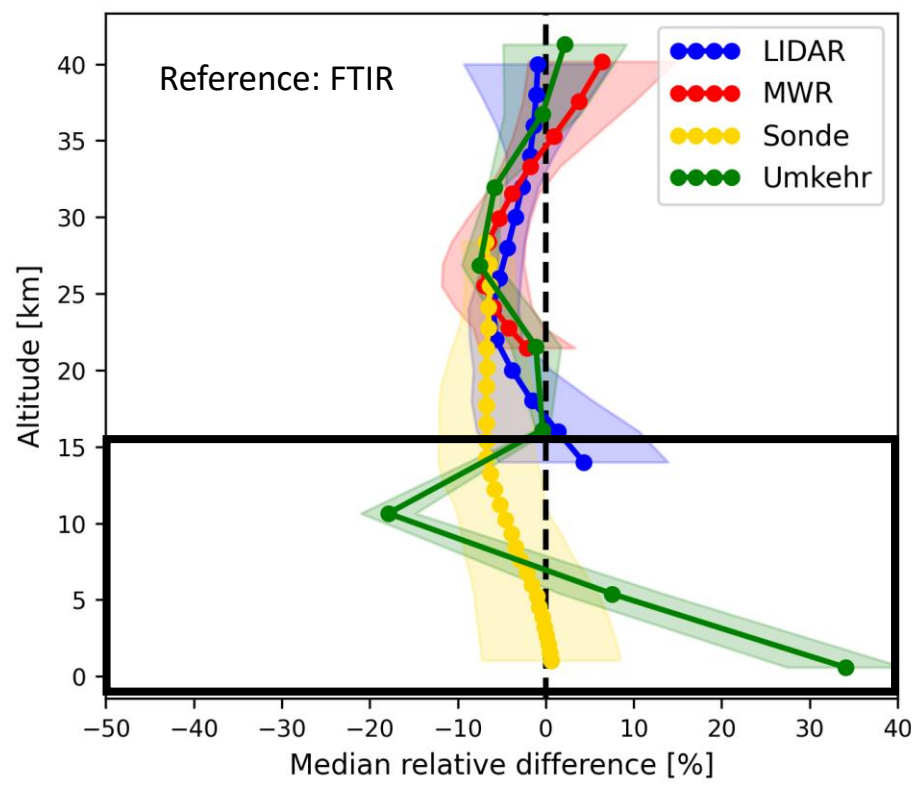
better agreement between **corrected** ozonesondes and tropospheric lidar at altitudes where instrument uncertainties are minimal!

Ancellet et al., AMT, 2022

# External Consistency: intercomparisons

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

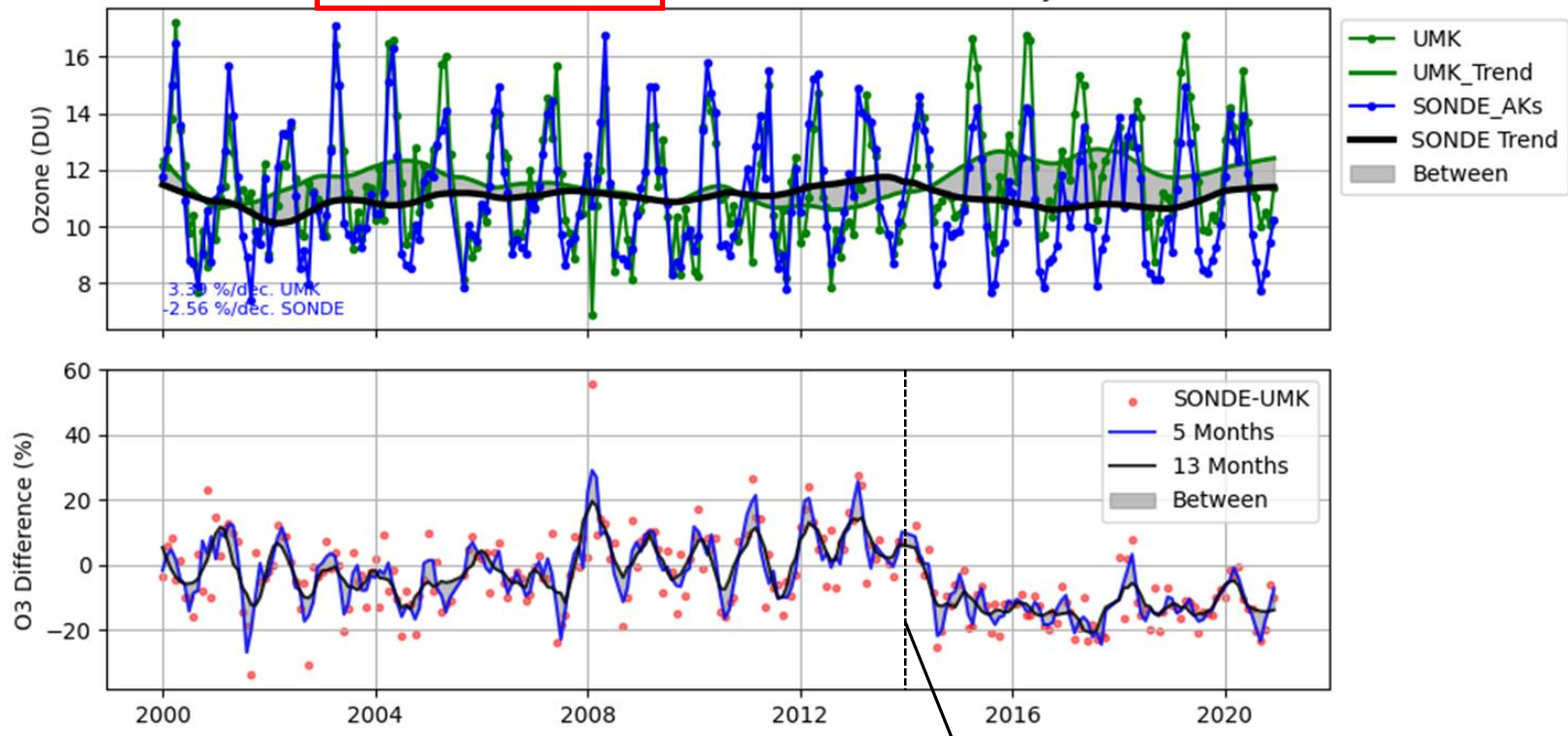
Lauder (New Zealand)



Björklund et al., in preparation

Mauna Loa (MLO) Hawaii (19.5 N, 155.6 W)

Layer 1: 1000 – 250 hPa



drop in tropospheric ozone content in ozonesonde in 2014

Effertz et al., in preparation

# Tropospheric ozone column trend estimates

## Starting point:

### Surface and tropospheric ozone trends

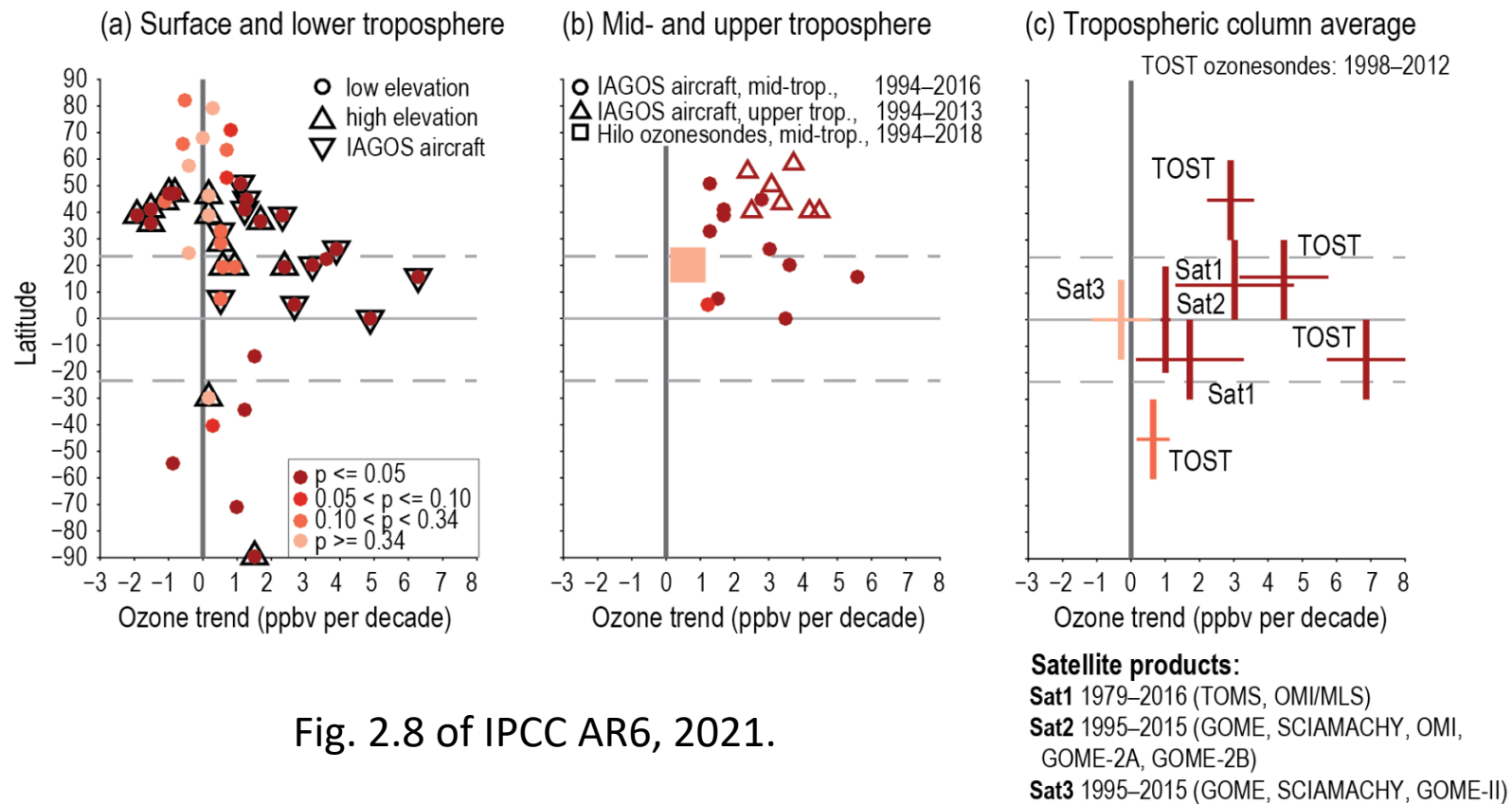


Fig. 2.8 of IPCC AR6, 2021.

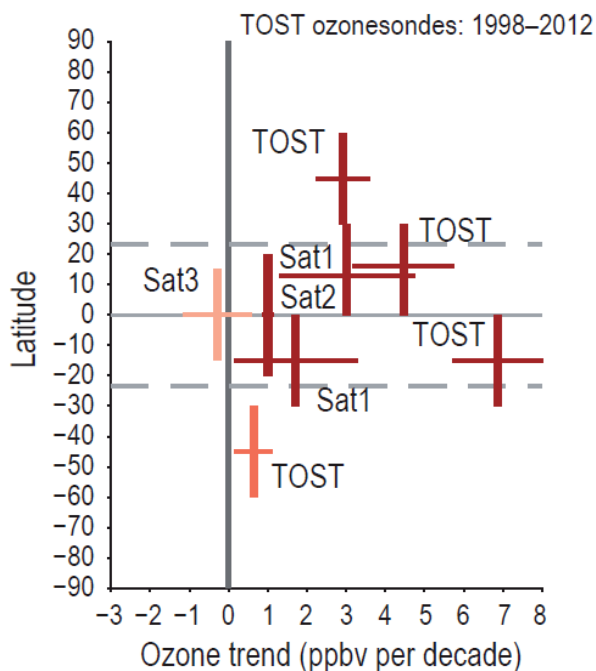
- for **individual** HEGIFTOM sites (ozonesondes, IAGOS, FTIR, Lidar, Umkehr)
- different (partial) tropospheric ozone column metrics
- consistency in used trend estimation tools (QR vs. MLR)
- consistency in time ranges (e.g. 2000-2002 till 2019-...)
- consistency in units (ppbv/dec vs. DU/dec)
- =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



# Tropospheric ozone column trend estimates

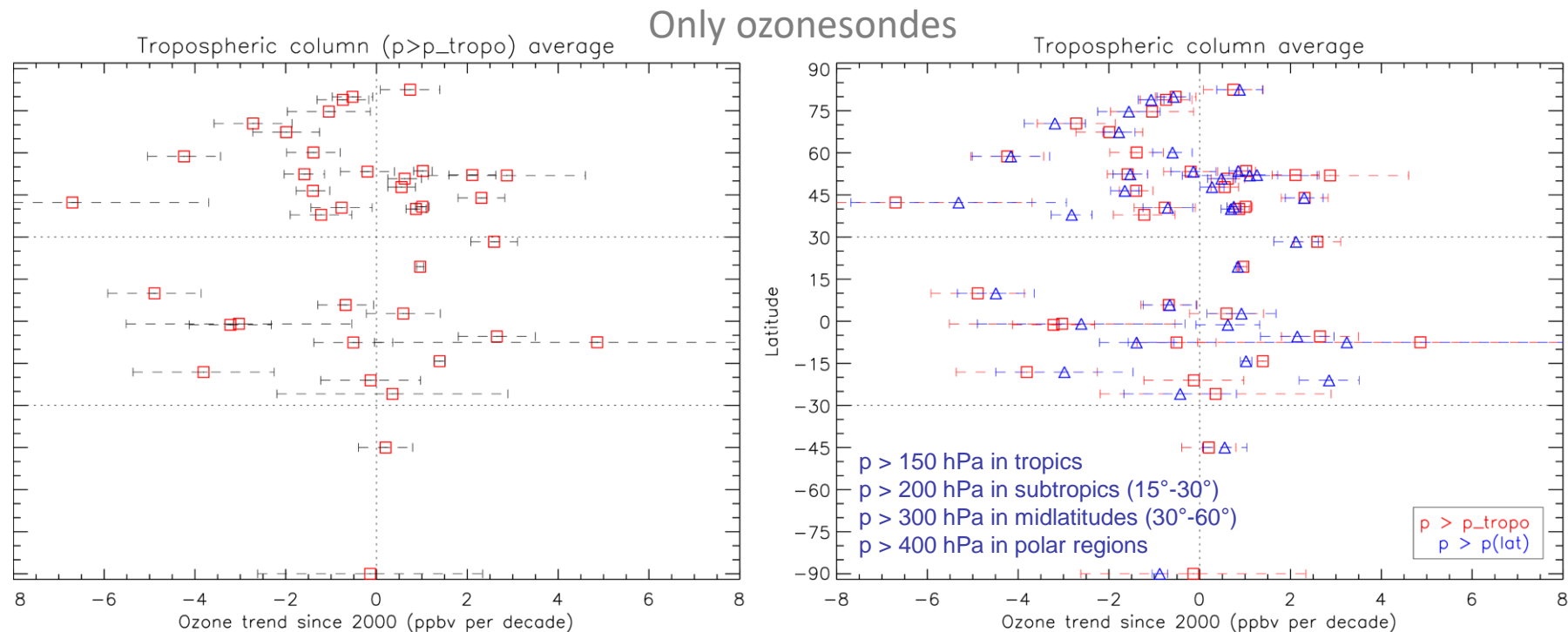
- all (partial) tropospheric ozone columns have been calculated for all sites/techniques

(c) Tropospheric column average



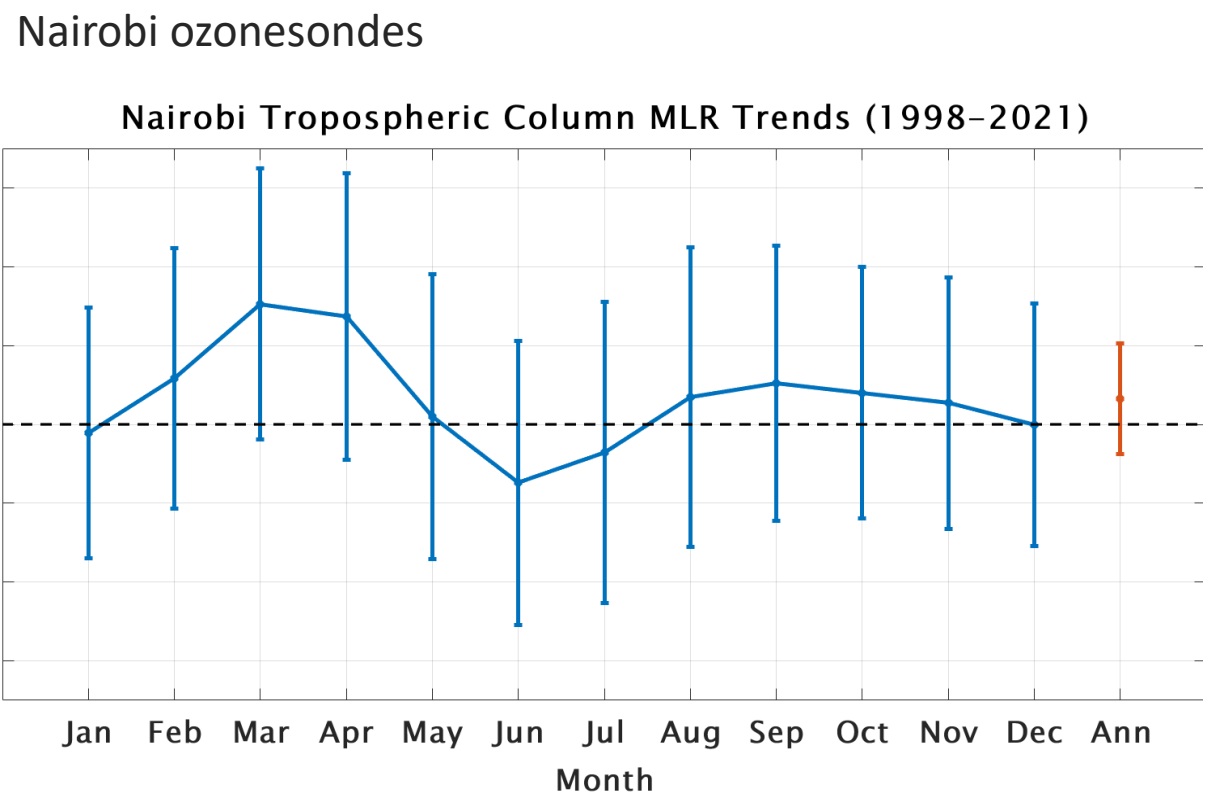
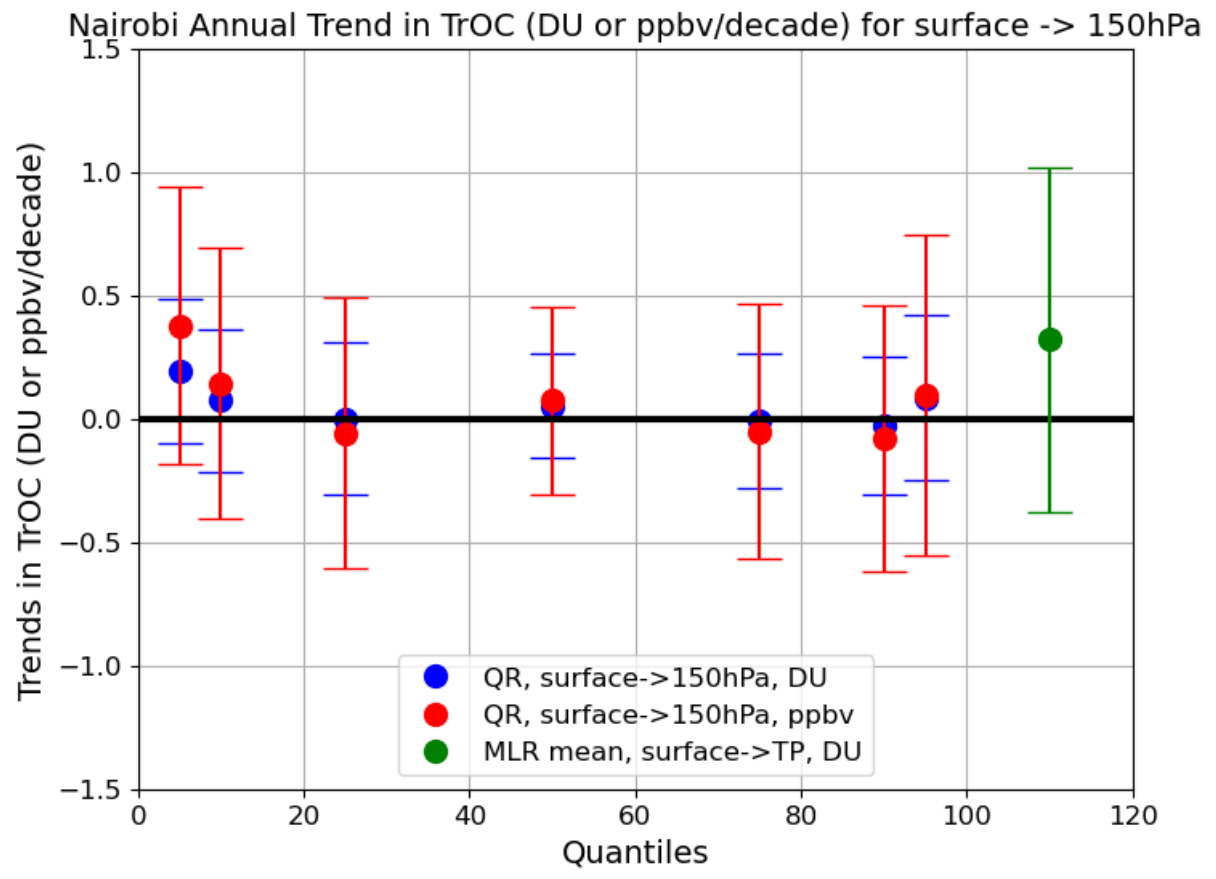
### Satellite products:

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



- 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



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>

