TOAR-II Activities

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http://hegiftom.meteo.be/

TOAR-II Primary goals, 2020-2024

Tropospheric Ozone Assessment Report, Phase II

TOAR Database: Updated with all recent ozone observations worldwide; add ozone precursors and meteorological data.

Final Product: An observation-based assessment of tropospheric ozone's distribution and trends on regional, hemispheric and global scales

(modelled after IPCC Working Group I)

Impact studies: will quantify the ***impacts*** of ozone on human health, vegetation and climate

(modelled after IPCC Working Group II)

TOAR-II Focus Working Groups

New research is being led by 16 independent **Focus Working Groups**:

- **Chemical Reanalysis** Focus Working Group
- **East Asia** Focus Working Group
- **Global and Regional Models** Focus Working Group
- **HEGIFTOM** Focus Working Group
- **Human Health** Focus Working Group
- **Machine Learning for Tropospheric Ozone** Focus Working Group
- **Ozone over the Oceans** Focus Working Group
- **Ozone and Precursors in the Tropics (OPT)** Focus Working Group
- **Ozone Deposition** Focus Working Group
- **Radiative Forcing** Focus Working Group
- **ROSTEES** Focus Working Group
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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).

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.

IAGOS


Ozonesondes


Brewer/Dobson Umkehr


FTIR


Lidar


MAX-DOAS & Pandora

http://hegiftom.meteo.be/datasets

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http://hegiftom.meteo.be/datasets

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 (Smit et al., in preparation)
- **Lidar**: TMF data has been updated with new data processor, OHP will follow
- **FTIR:** flagging applied to the NDACC data
- **Brewer/Dobson Umkehr**:
  - 6 Dobson Umkehr sites have been homogenized (Petropavlovskikh et al., https://doi.org/10.5194/amt-15-1849-2022)
  - Updated uncertainty estimation of the retrievals.
- **ozonesondes**:
  - 12 more sites homogenized, e.g. OHP, Lauder, Arctic sites (10-15/55 remaining)
  - homogenized data available on ftp-server

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

Deliverable: time series of different (partial) tropospheric ozone column amounts

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

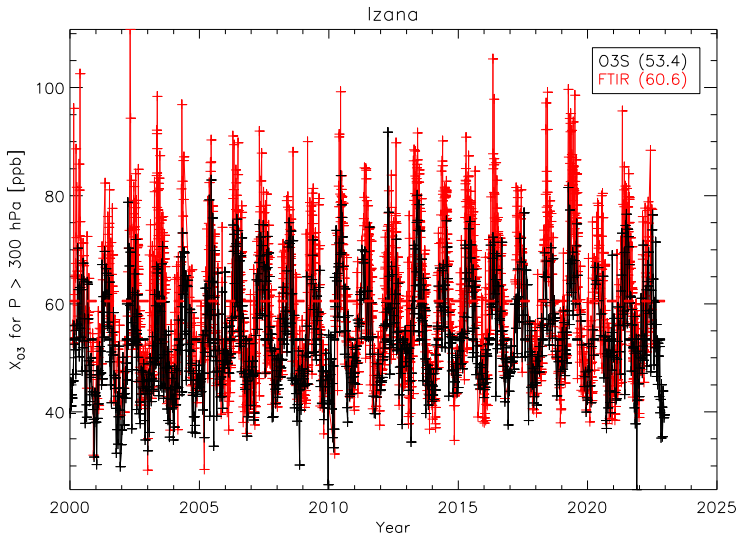
} the 2 recommended TOAR-II tropospheric ozone column definitions

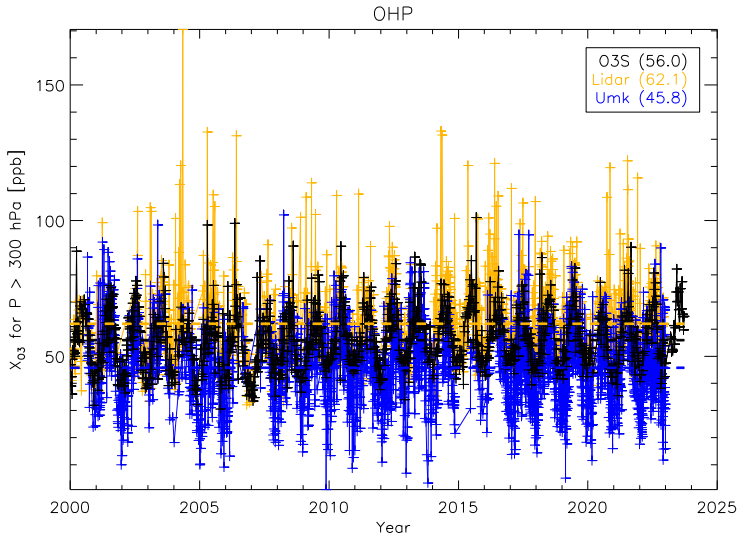
- for all sites/techniques, if feasible
- provided for all measurements (**L1**), together with daily means (**L2**) and monthly means (**L3**)
- available in DU or ppb
- uncertainties included (random, systematic, total, statistical)
- simple csv files, with readme files per technique

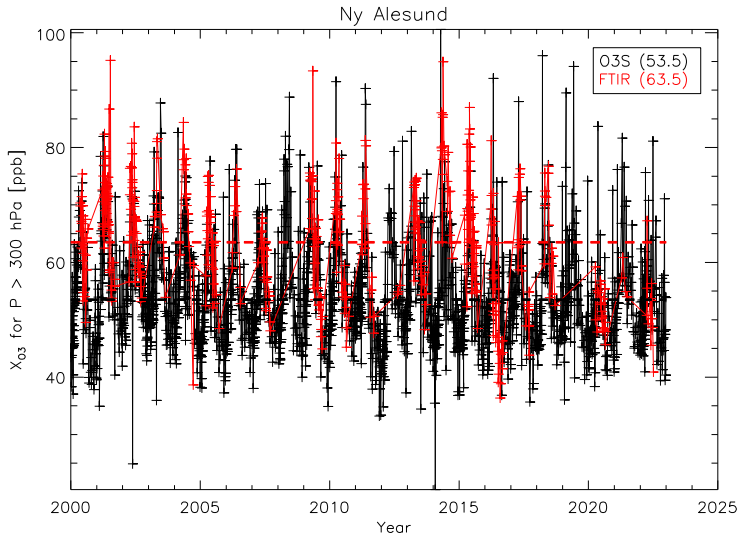
https://hegiftom.meteo.be/datasets/tropospheric-ozone-columns-trocs

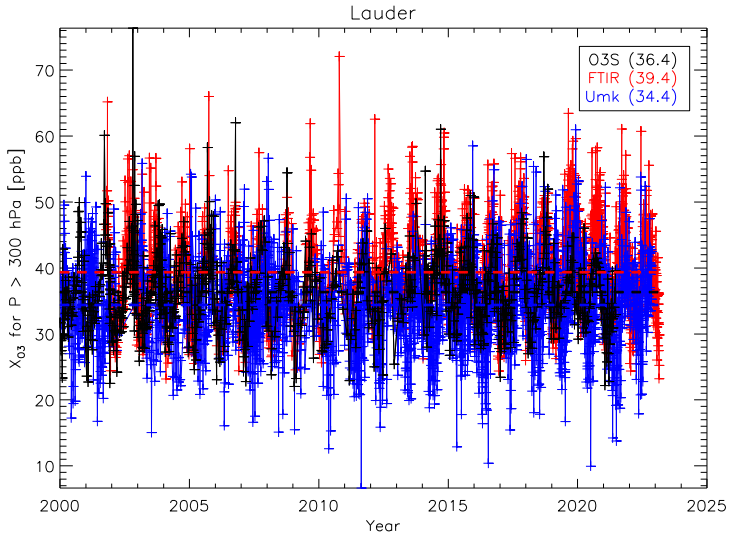
Intercomparisons

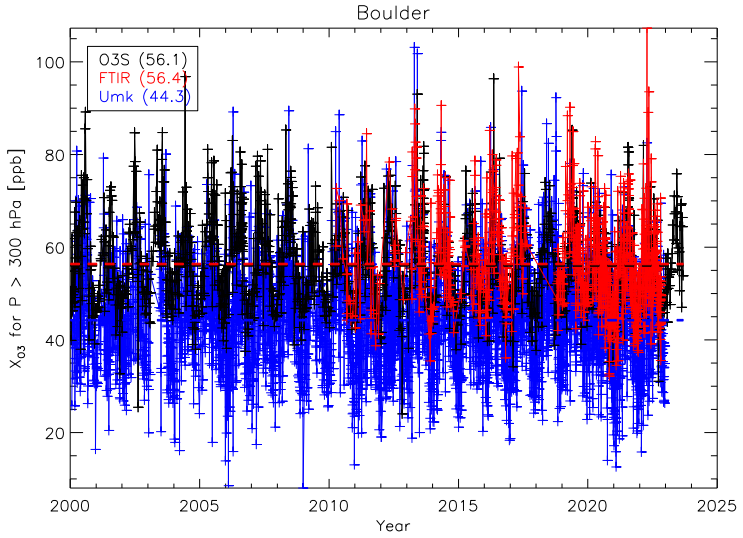
Deliverable: @ Lauder (Björklund et al., 2024), between IAGOS and sondes (Wang et al., 2024)

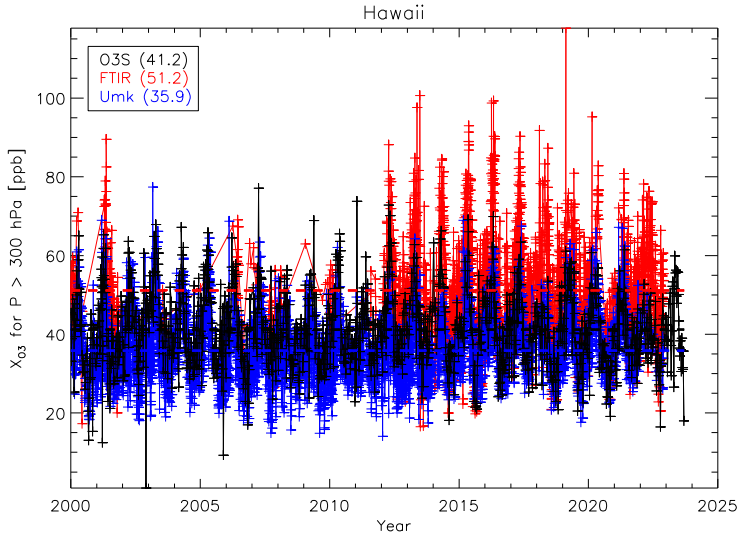












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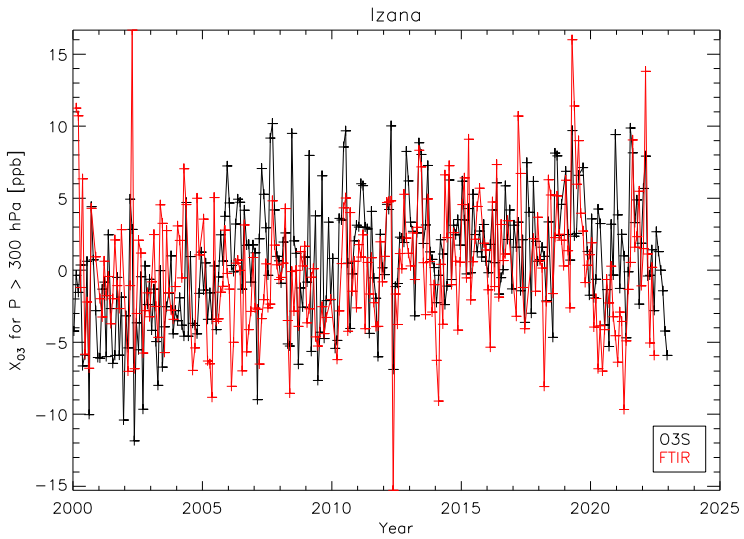
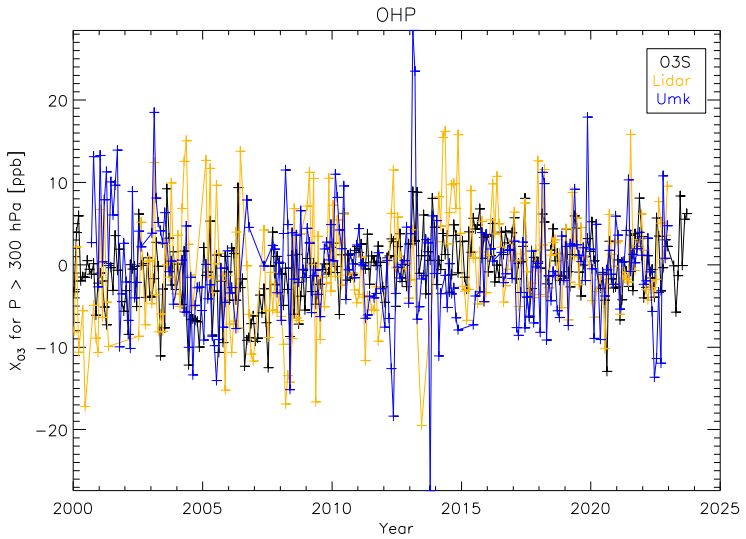
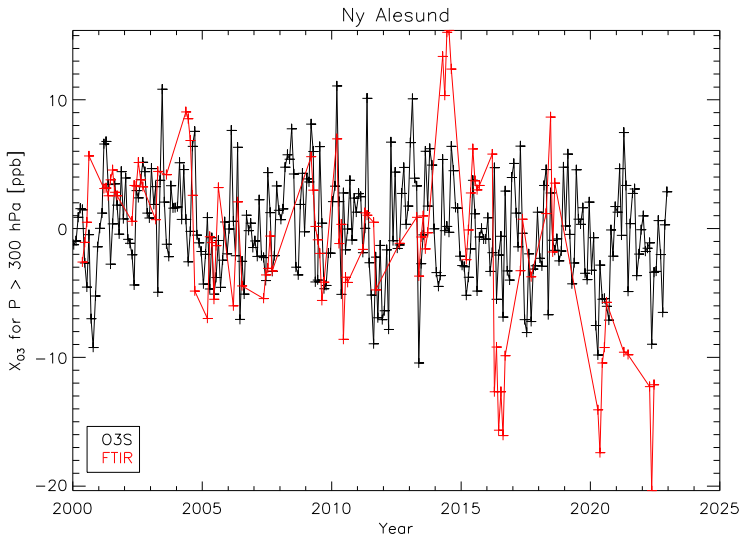
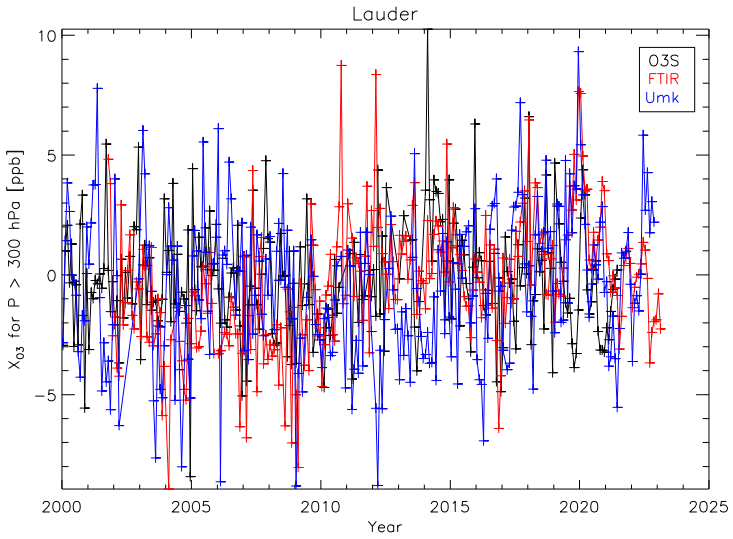
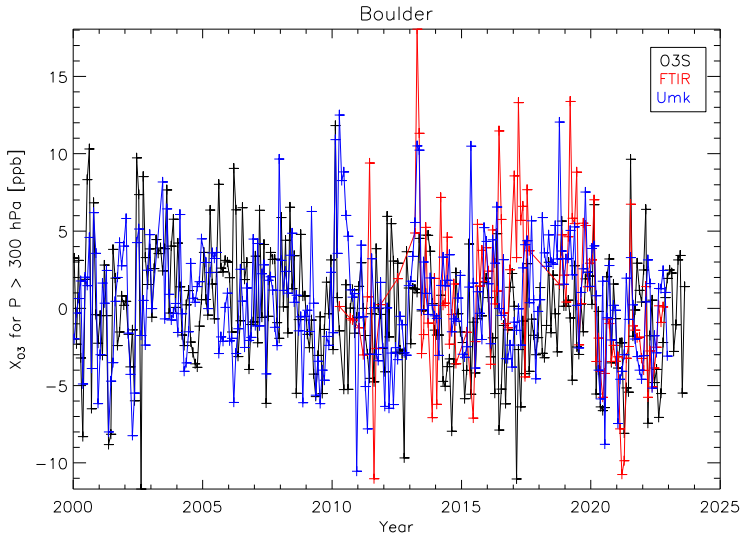
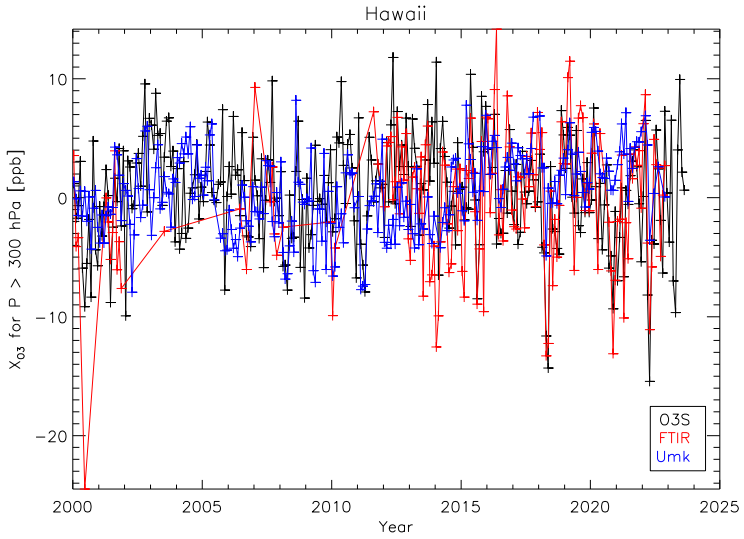








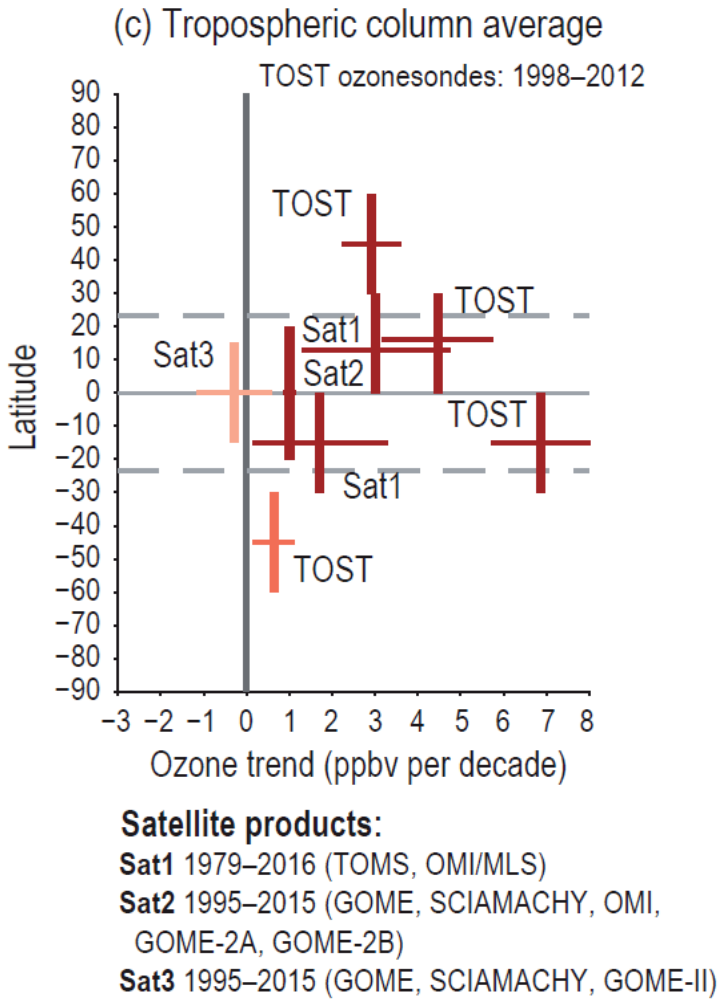




Tropospheric ozone column trends

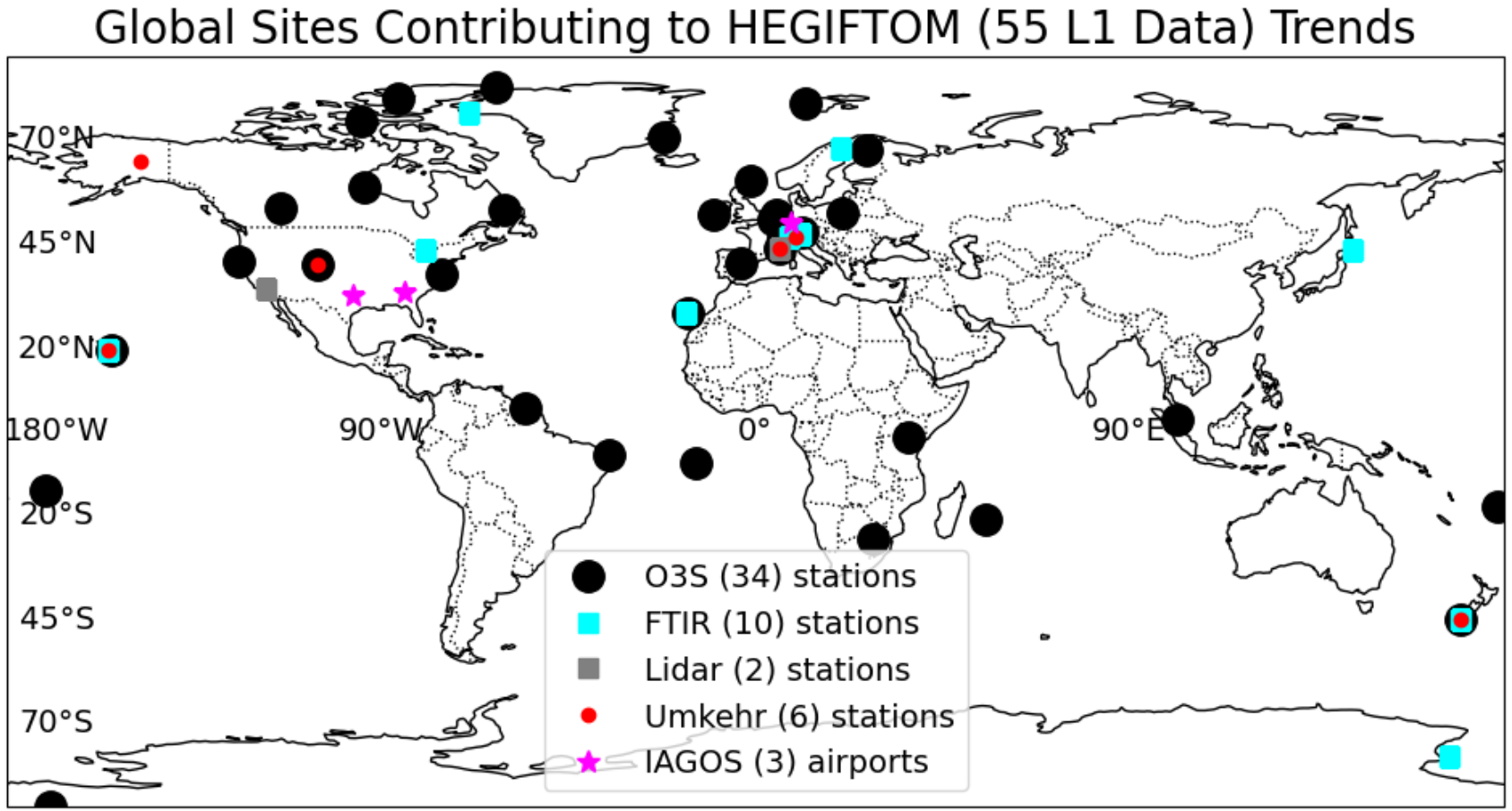
- TOAR-II: tropospheric ozone **trends** assessment
- In literature:

Fig. 2.8 of
IPCC AR6, 2021.



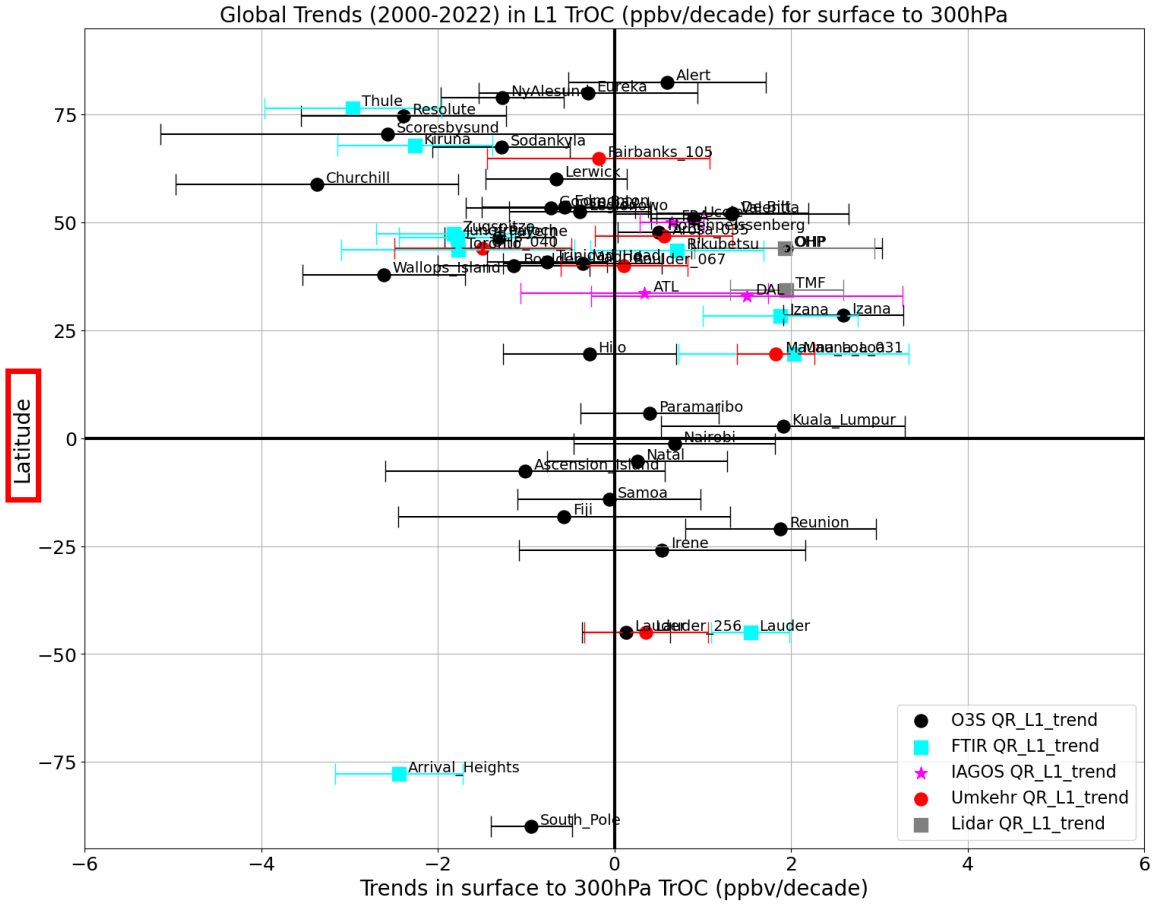
- ✓**Here**: focus on high-quality **ground-based** and **in-situ** measurements (individual sites + "merged")
- ✓Consistency in tropospheric ozone column metric (**here**: surface to 300 hPa)
- ✓Consistency in used trend estimation tools (QR vs. MLR)
- ✓Consistency in time ranges (here: 2000-2002 till 2019-2022)
- ✓Consistency in units (ppbv/dec)

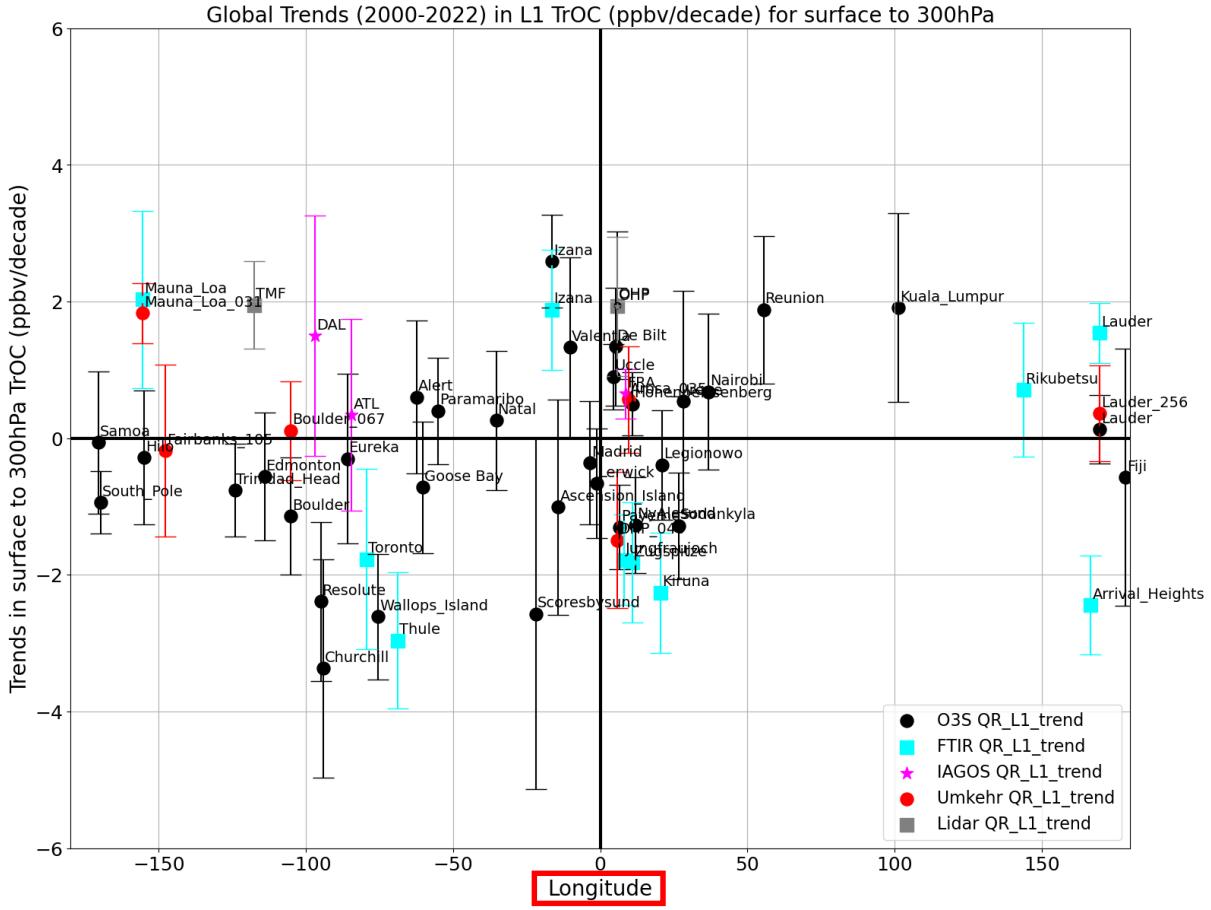
Individual site trends



- Sampling and gaps put constraints
- 55 sites

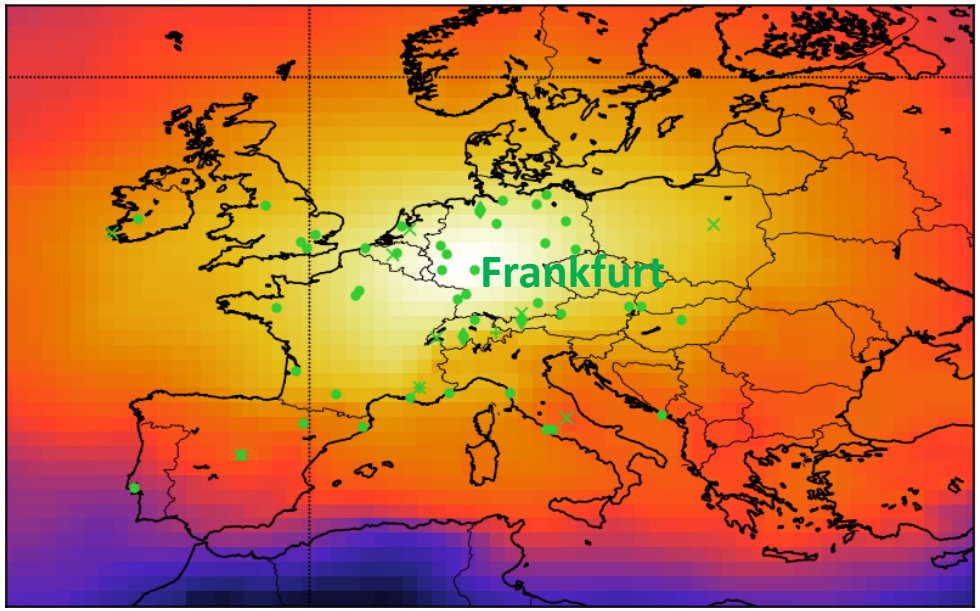
Individual site trends: QR median trends

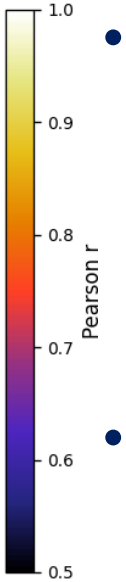




- see more results in Debra Kollonige's talk tomorrow, Thursday!

Strategy for regionalized trends

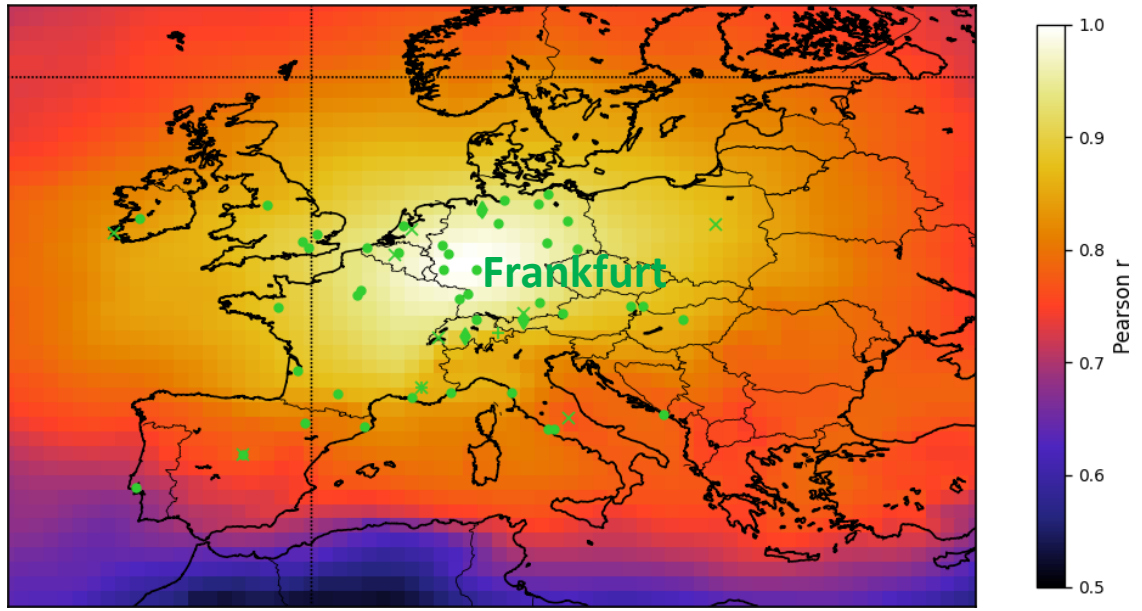




- Correlation maps between CAMS TrOC (sfc – 300 hPa) monthly anomalies at HEGIFTOM sites (here: Frankfurt, IAGOS)
- r > 0.7!

Strategy for regionalized trends

1.
regions



Trends in defined regions with

TOST (Trajectory-mapped

Ozonesonde dataset for the

Stratosphere and Troposphere):

ozonesondes only!

→ Zang et al., accepted for ACP, 2024

Strategy for regionalized trends

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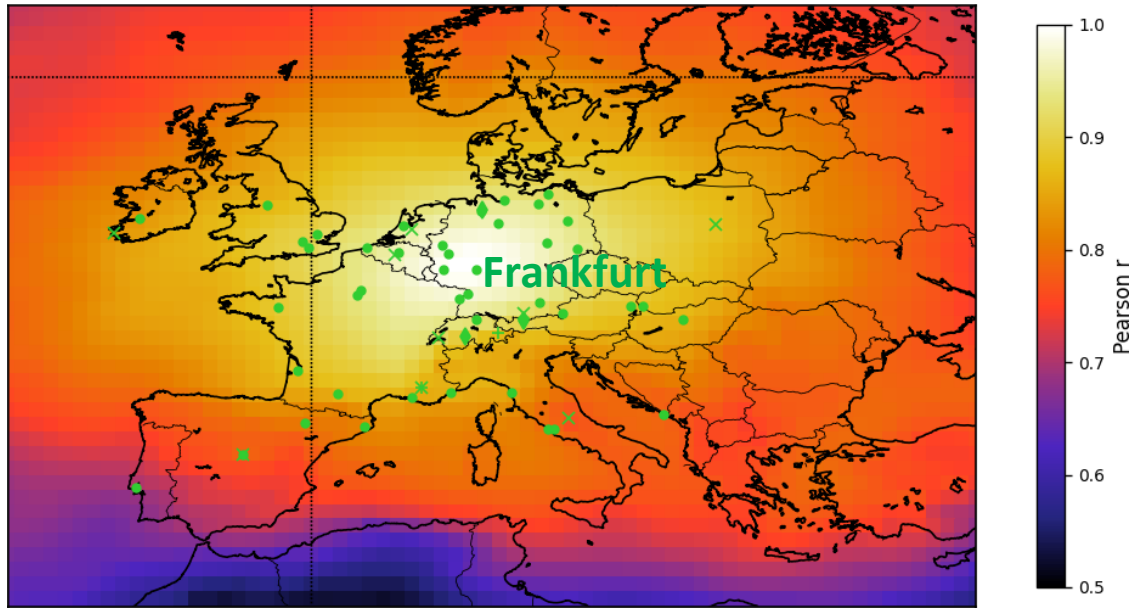


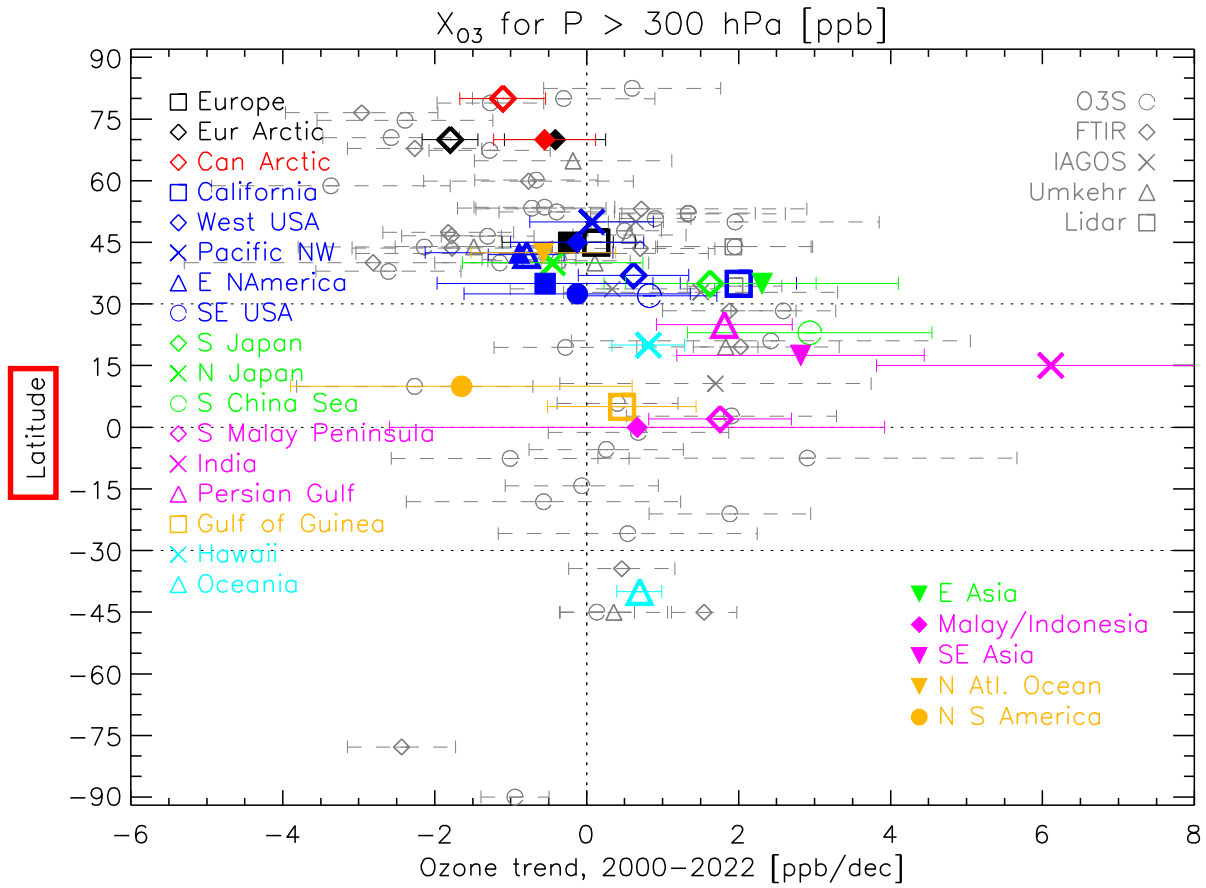
2. sites

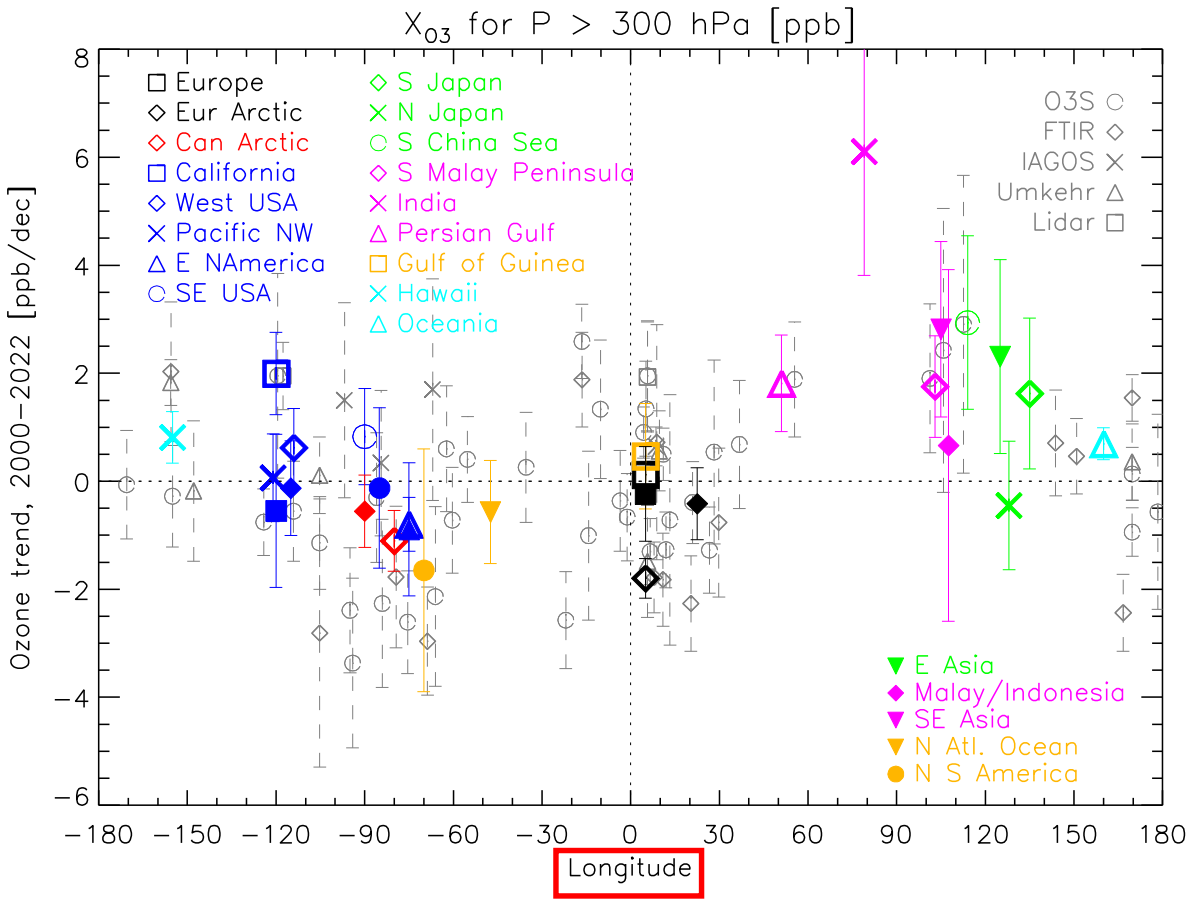
Trends in defined regions with TOST (Trajectory-mapped Ozonesonde dataset for the Stratosphere and Troposphere): **ozonesondes only**!

→ Zang et al., accepted for ACP, 2024

Statistical method for calculating synthetized trends from **well-correlated individual time series for all instruments**, allowing an intercept and a slope to adjust the difference from each individual trend against the overall trends

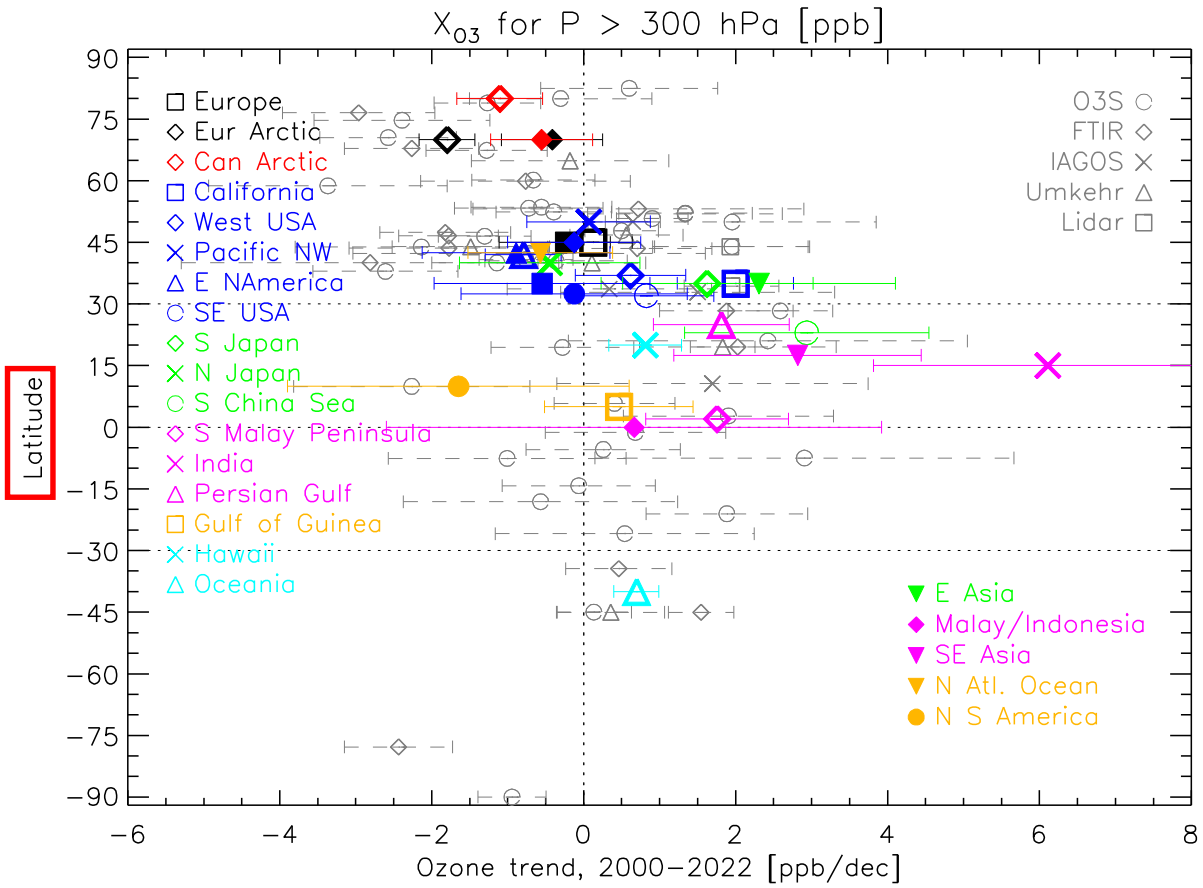
All trends

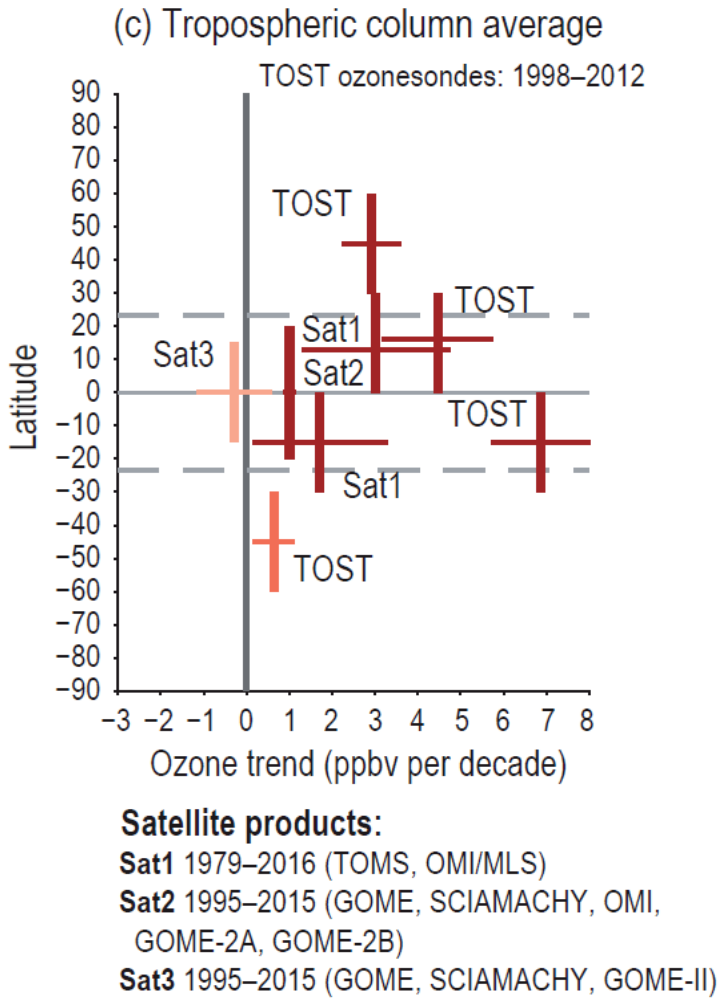




background grey = individual site trends
different colors = different regions
open symbols = synthesized trends
filled symbols = TOST regional trends

All trends





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)

background grey = individual site trends
different colors = different regions
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Conclusions and outlook

- without NDACC, no HEGIFTOM
- HEGIFTOM data (O3S!!!) should feed back into NDACC
- Tropospheric ozone distribution and trends with ground-based data really pushed to the limits: best (possible) effort done.
- More results (post-COVID vs. pre-COVID, 1990/1995/2000 – 2022 trend comparisons, relative contribution of lower+free-tropospheric ozone column trends to entire tropospheric ozone column trends, TrOC seasonal cycle change, etc.):

Conclusions and outlook

- More results:
  - ✓ Debra Kollonige's talk tomorrow
  - ✓ Van Malderen et al., "**Global Ground-based Tropospheric Ozone Measurements: Reference Data and Individual Site Trends (2000-2022) from the TOAR-II/HEGIFTOM Project**" *(working title)*, to be submitted to ACP (TOAR-II SI)
  - ✓ Van Malderen et al., "**Global Ground-based Tropospheric Ozone Measurements: Regional tropospheric ozone column trends from the HEGIFTOM homogenized ground-based profile ozone datasets**" *(working title)*, to be submitted to ACP (TOAR-II SI)