GOME-Type tropical tropospheric ozone and S5P-BASCOE tropospheric ozone

- Klaus-Peter Heue, Diego Loyola, Melanie Coldewey-Egbers, Martin Dameris, Christophe Lerot, Michel van Roozendael, Daan Hubert, Simon Chabrillat, Quentin Errera

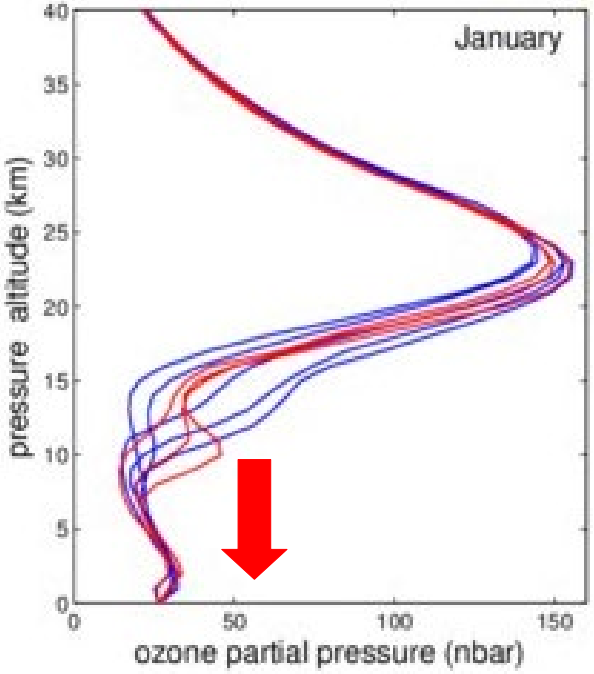
- 15 Sept. 2023

Overview

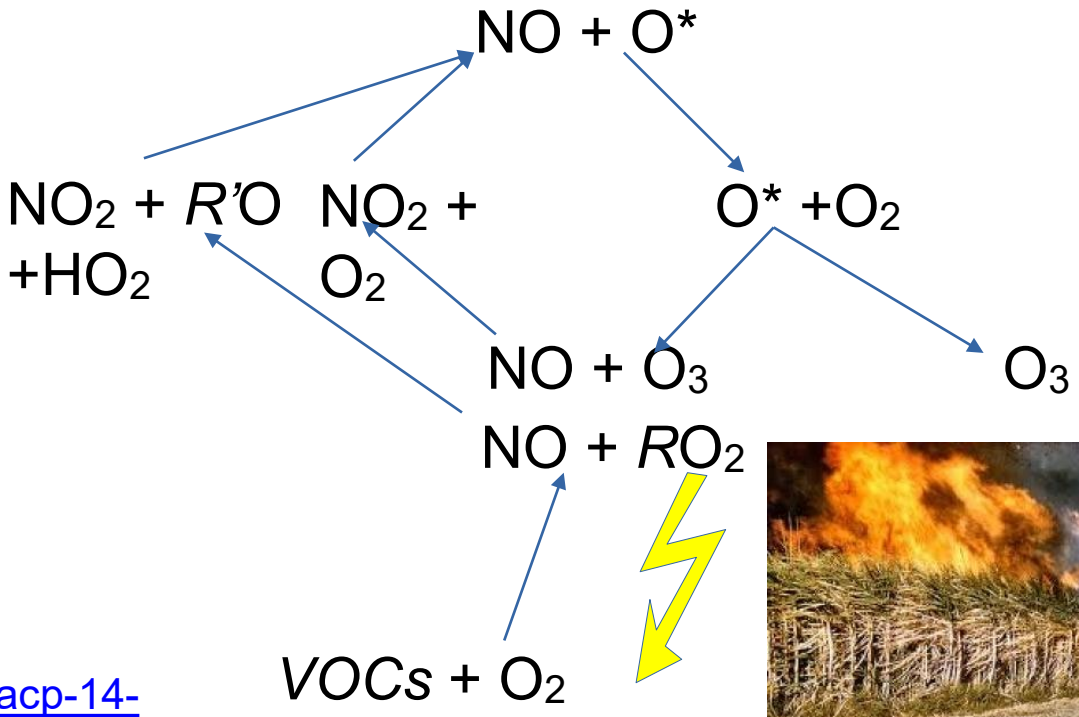
- Motivation
- CCD (convective cloud Differential) tropics only
  - Principle
  - Harmonisation
  - Trends
    - Comparison to EMAC simulations
- S5p-BASCOE global
  - Principle
  - Comparison to OMPS-MERRA2
  - Application to GOME-Type Ozone -ECV

Sources of tropospheric Ozone

Downwards transport ~10%



Chemical Production ~90%



Sofieva et al. 2014 DOI: 10.5194/acp-14-283-2014

nature food

ARTICLES

https://doi.org/10.1038/s43016-021-00422-6

Check for updates

Published Jan. 2022

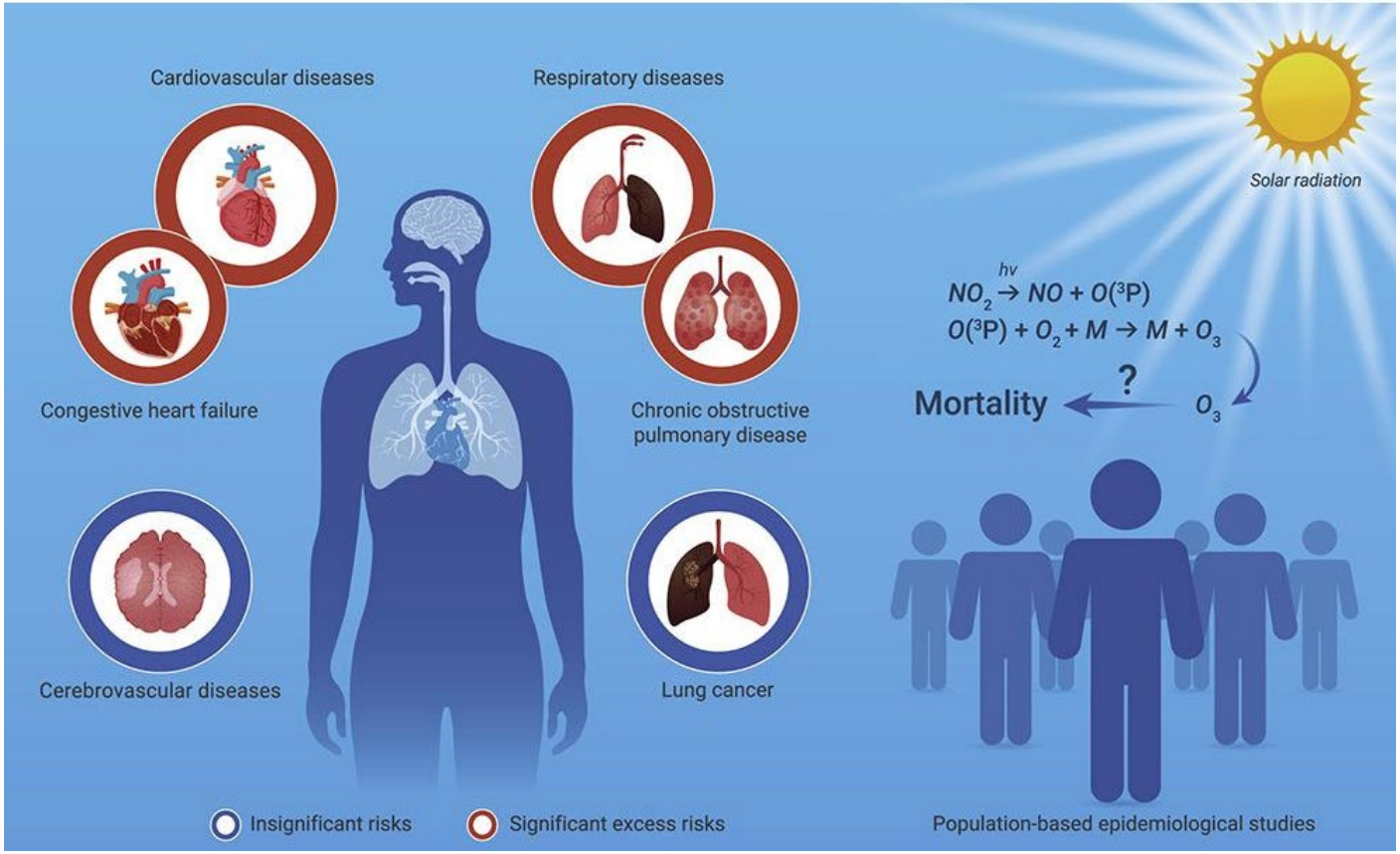
Ozone pollution threatens the production of major staple crops in East Asia

Zhaozhong Feng[1,10] ✉, Yansen Xu[1,10], Kazuhiko Kobayashi[2,10] ✉, Lulu Dai[1,3], Tianyi Zhang[4], Evgenios Agathokleous[1], Vicent Calatayud[5], Elena Paoletti[6], Arideep Mukherjee[1,7], Madhoolika Agrawal[7], Rokjin J. Park[8], Yujin J. Oak[8] and Xu Yue[9] ✉

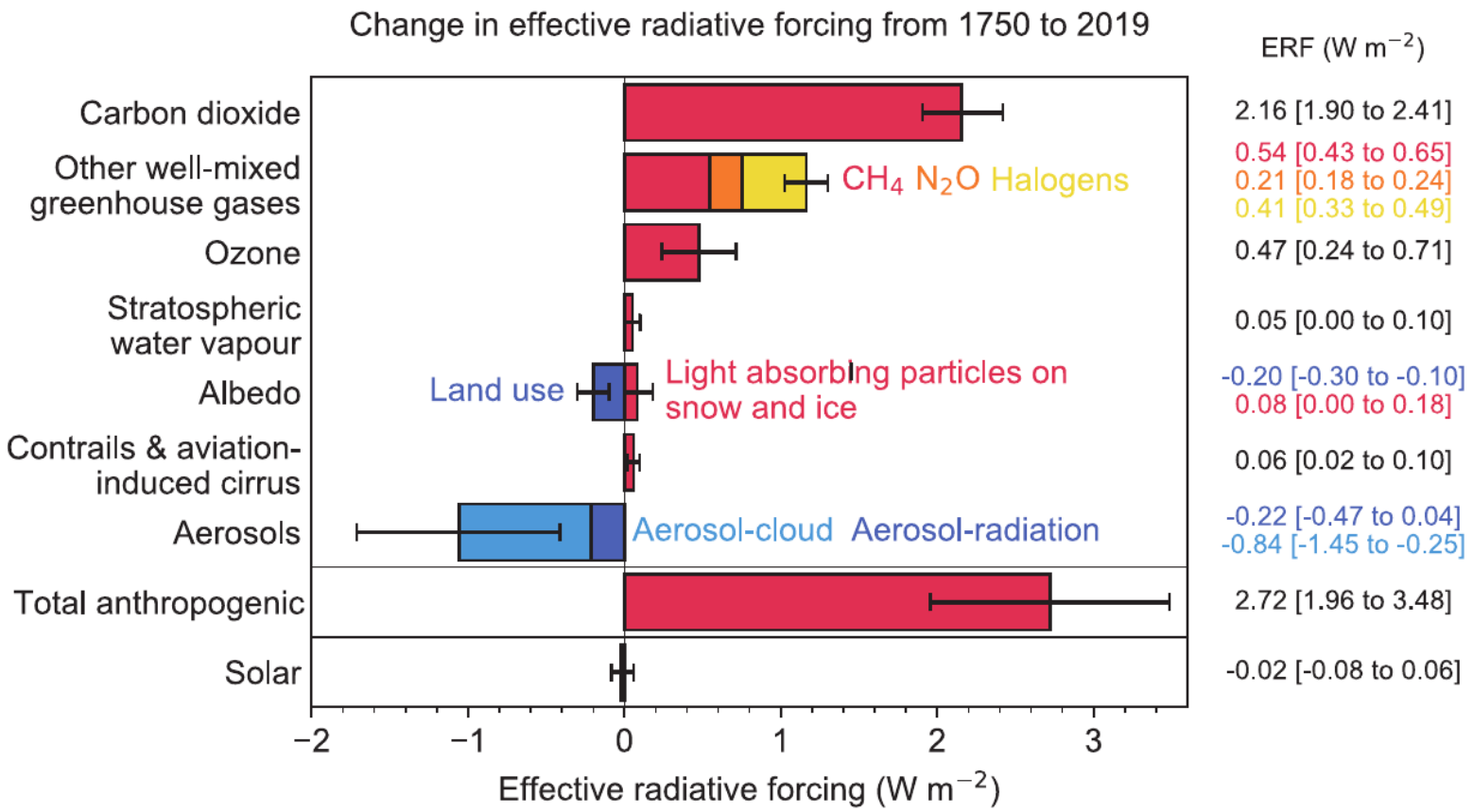
East Asia is a hotspot of surface ozone (O_3) pollution, which hinders crop growth and reduces yields. Here, we assess the relative yield loss in rice, wheat and maize due to O_3 by combining O_3 elevation experiments across Asia and air monitoring at about 3,000 locations in China, Japan and Korea. China shows the highest relative yield loss at 33%, 23% and 9% for wheat, rice and maize, respectively. The relative yield loss is much greater in hybrid than inbred rice, being close to that for wheat. Total O_3-induced annual loss of crop production is estimated at US$63 billion. The large impact of O_3 on crop production urges us to take mitigation action for O_3 emission control and adaptive agronomic measures against the rising surface O_3 levels across East Asia.

Tropospheric ozone (O_3) is a secondary air pollutant produced

assess the yield losses induced by ambient O_3. Estimates of yield loss



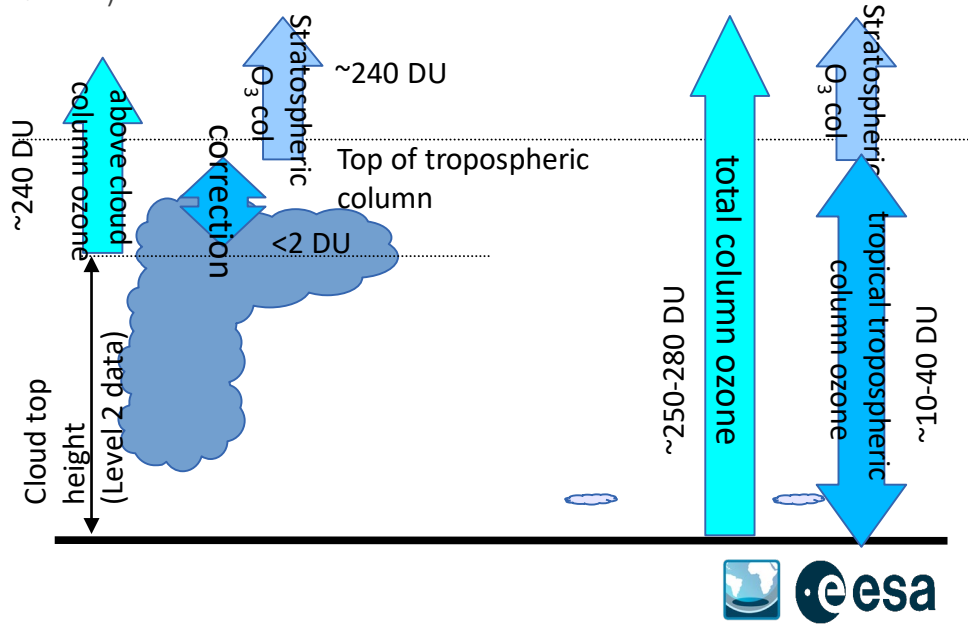
Haitong Zhe Sun et al., 2022: Cohort-based long-term ozone exposure-associated mortality risks with adjusted metrics: A systematic review and meta-analysis https://doi.org/10.1016/j.xinn.2022.100246



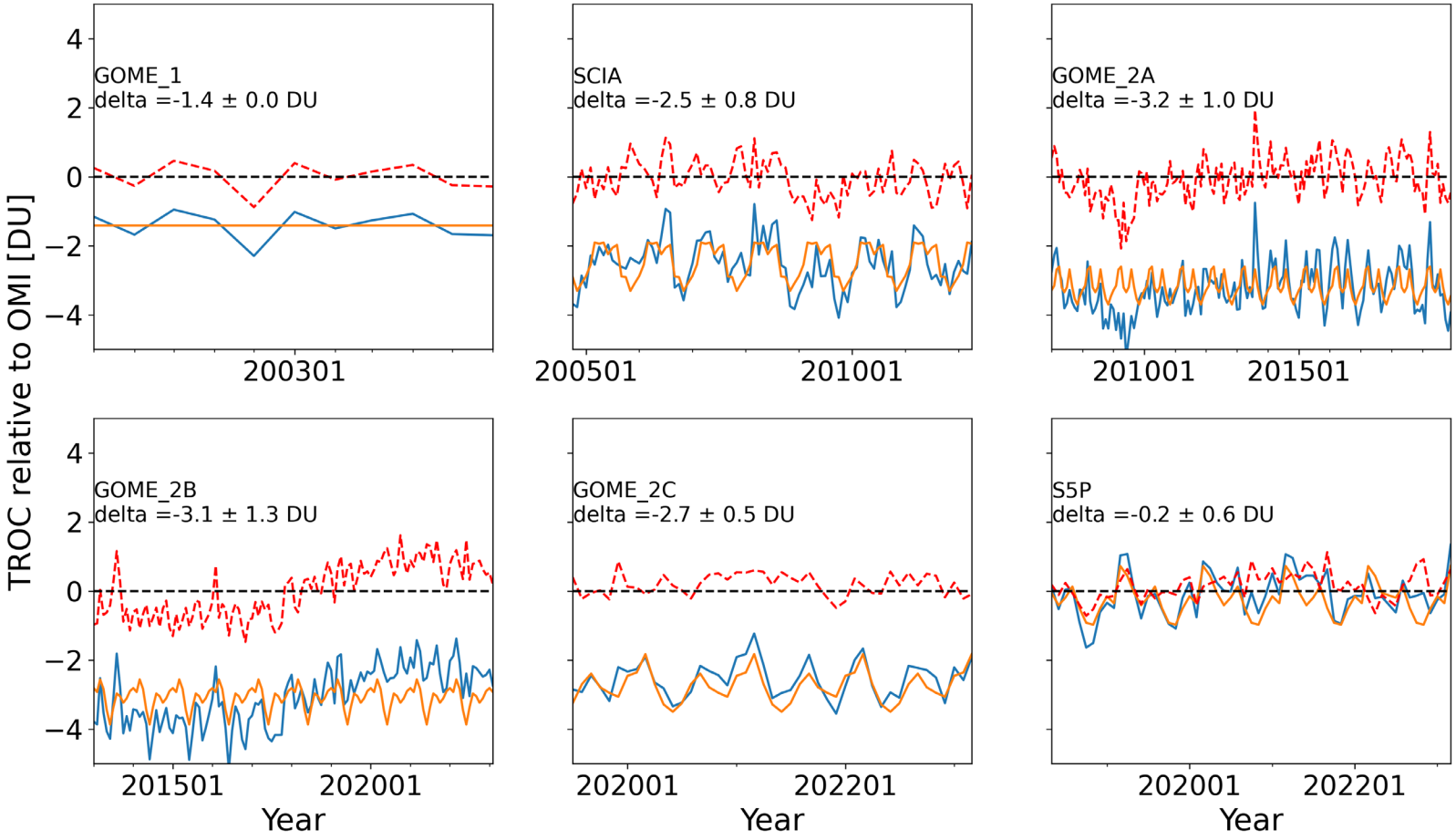
https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter07.pdf

details CCD Specifications

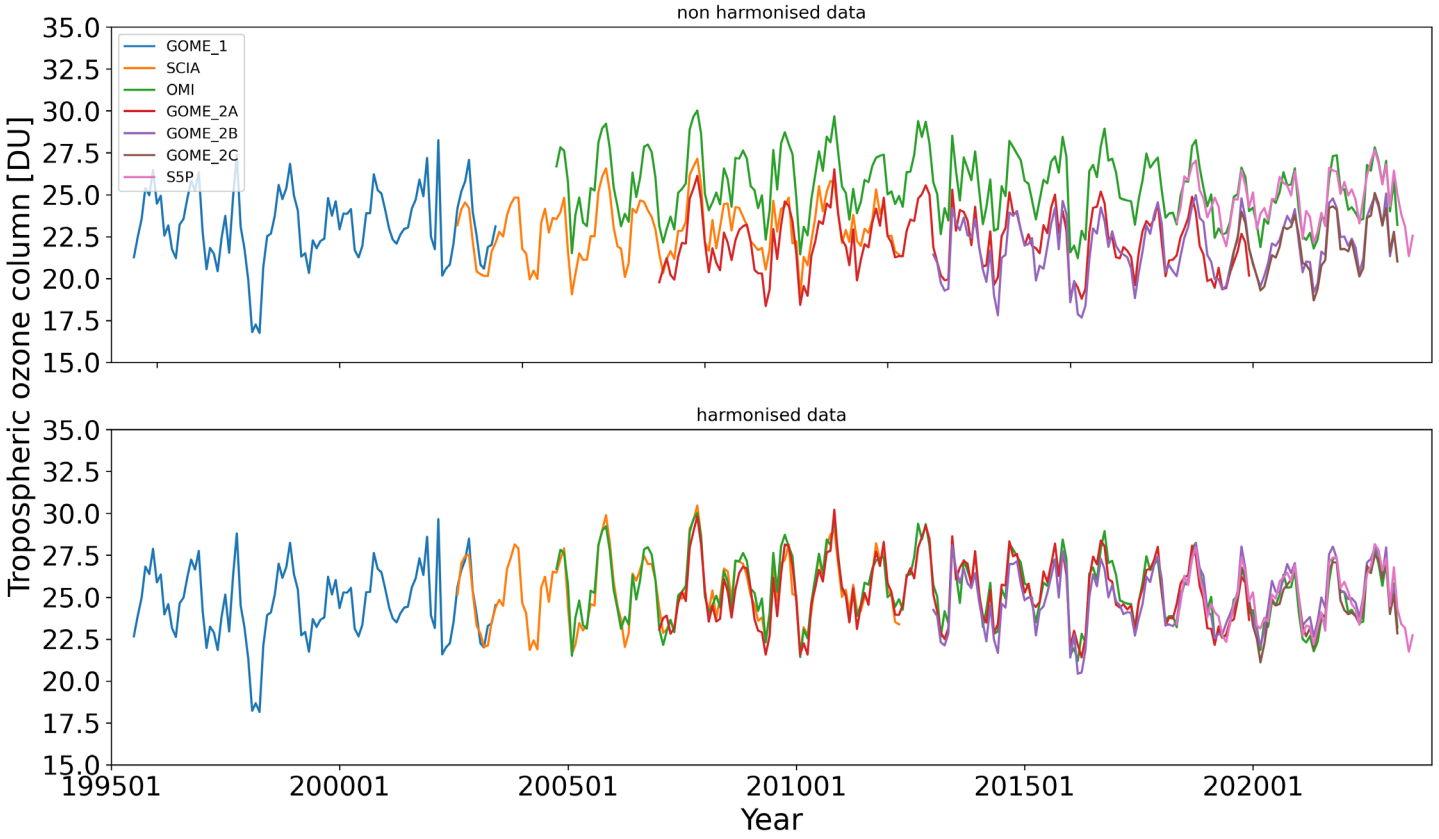
- definition tropospheric column, close to the top of deep convective clouds
- Two data sets:
  - 270 hPa operational S5P RPRO data
  - 200 hPa S5P internally processed
- Stratospheric column is averaged over 70°E to 190 °E (=170°W)
- CCD files also contain averaged VMR
- spatial & temporal sampling, 1°x1° x 1month
- S5P data are averaged to the spatial and temporal resolution (op. 0.5° x 1°x 3 days)



Harmonisation 200 hPa



Harmonisation

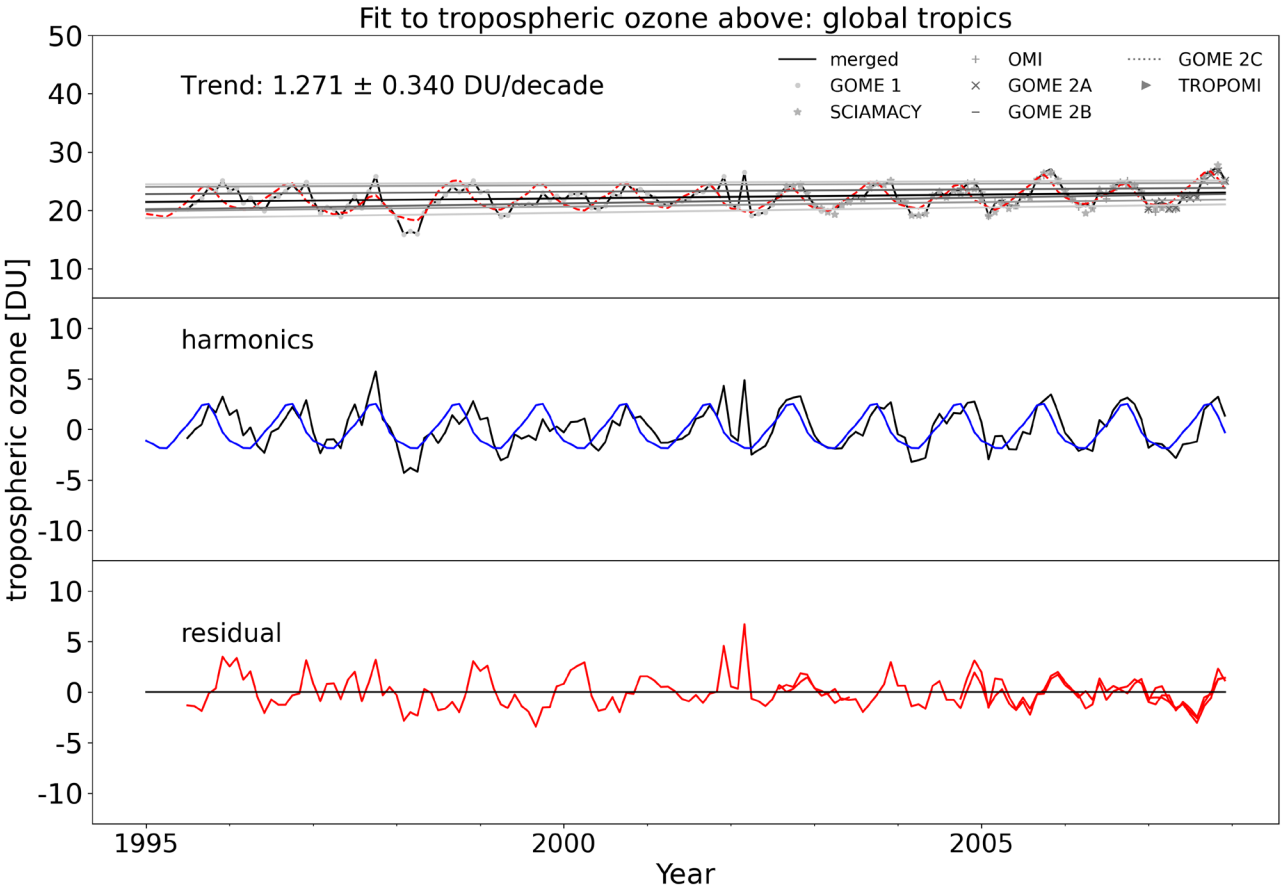


Trend Results

- Fit Trends from 1995 to 2008
- And from 2008 to 2022

- For the trends the percentile trends are recommended

Trend between 1995 and 2007



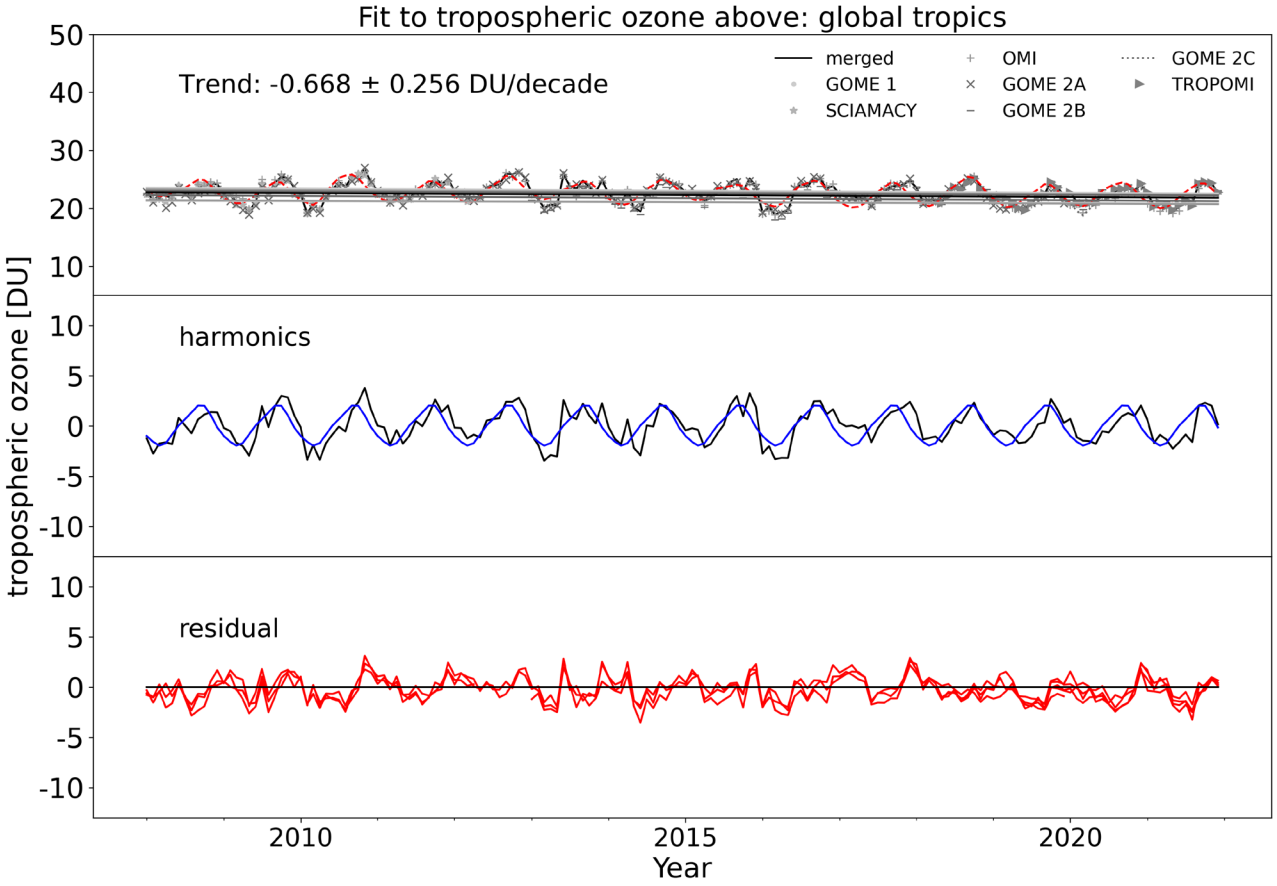
Increase

~ 1.23 DU/decade

~ 4.6 Tg/decade

startyear	Trend DU/ decade
1996	1.17
1997	1.43
1998	2.64
1999	

Trend between 2008 and 2022



Decrease

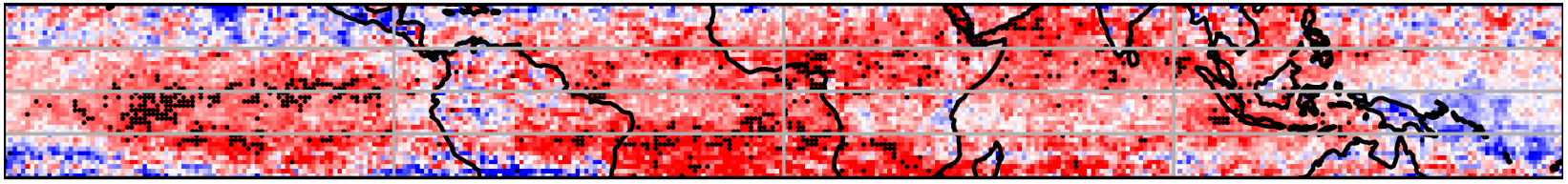
~ 0.71 DU/decade

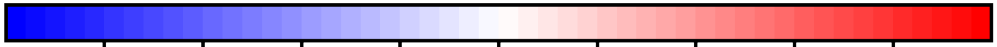
~ 2.7 Tg/decade

Trends 1995-2023

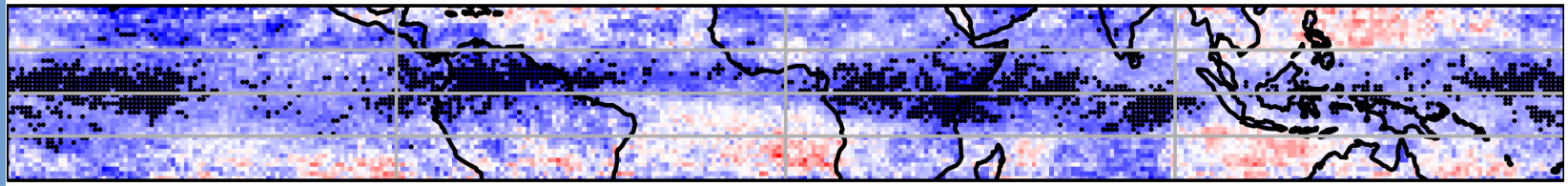
The same fit was applied for each grid point, the median slope is shown here, the dots indicate significant trends

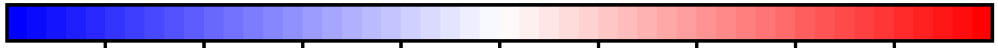
trend in tropospheric column ozone



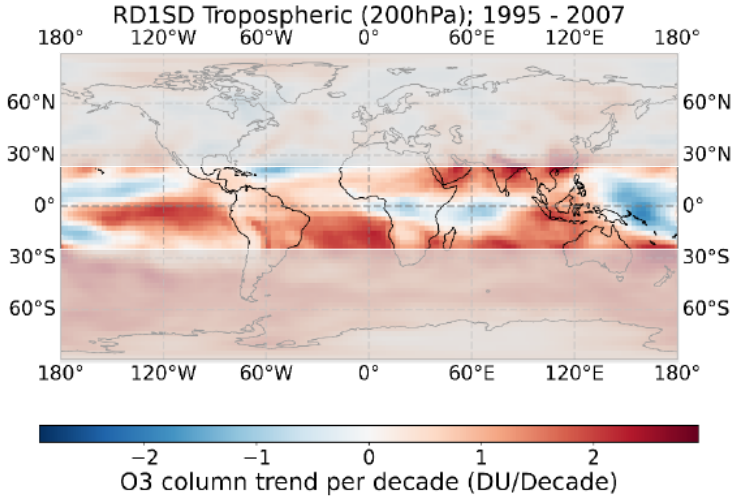


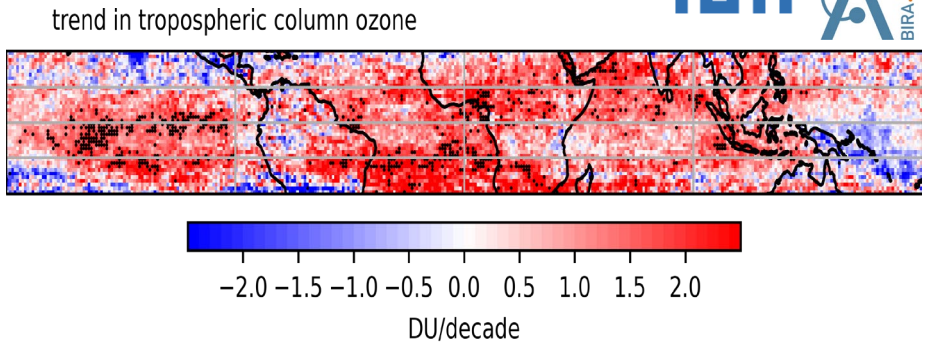
trend in tropospheric column ozone

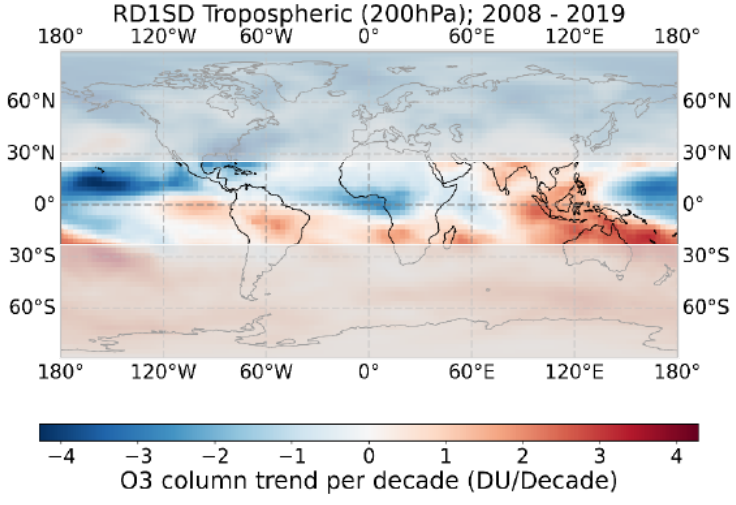


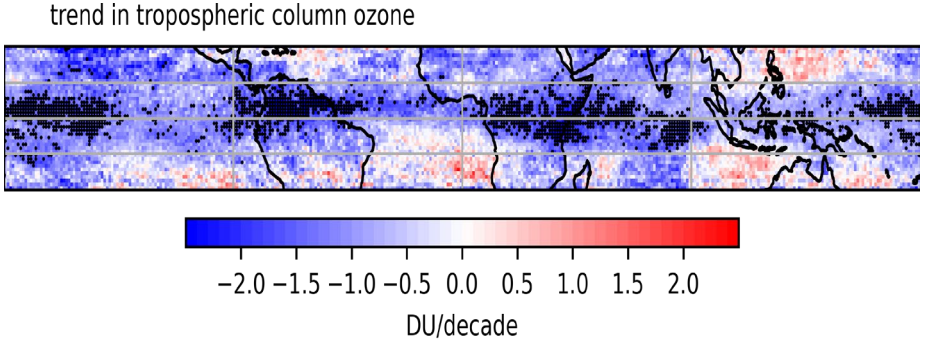


EMAC simulation

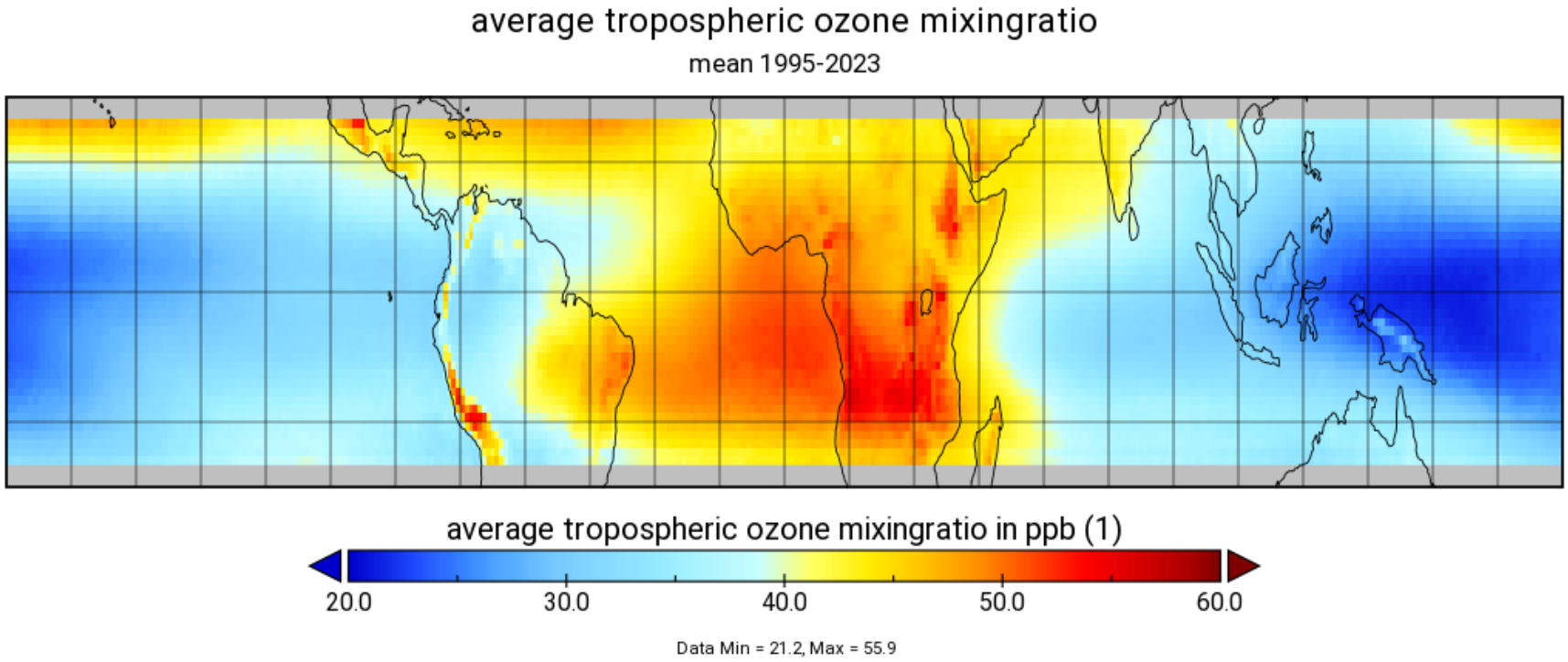








Mean map and temporal change

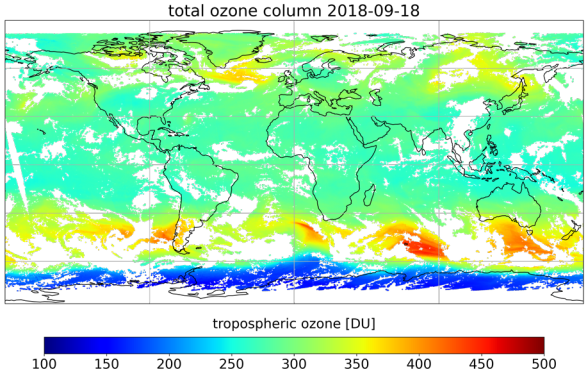


Summary and outlook CCD

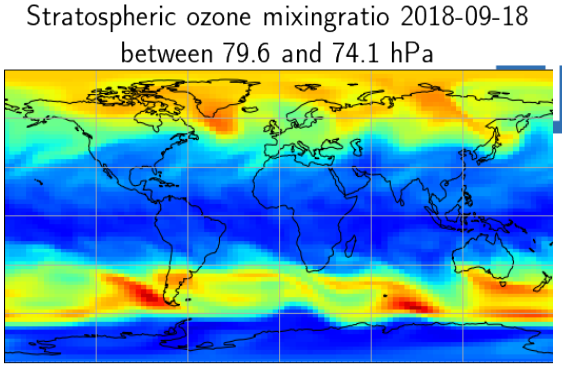
- Harmonized CCD tropical tropospheric data set from 1995-2022
- Mean tropical trend
  - up to 2007 +1.2 DU/decade or 4.5 Tg/decade
  - between 2008 and 2022 -0.67 DU/decade or -2.5 Tg/decade

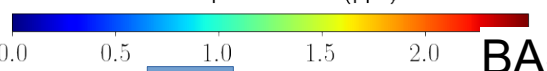
- Update publication from 2016

S5P - BASCOE

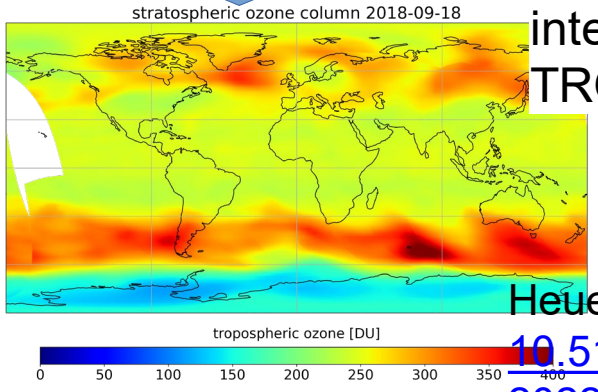


TROPOMI total column ozone cloud free (cf<0.2)

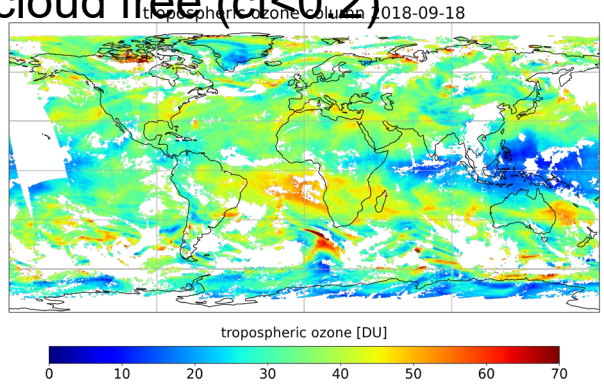




BASCOE ozone profile integrated above tropopause an interpolated to TROPOMI pixel

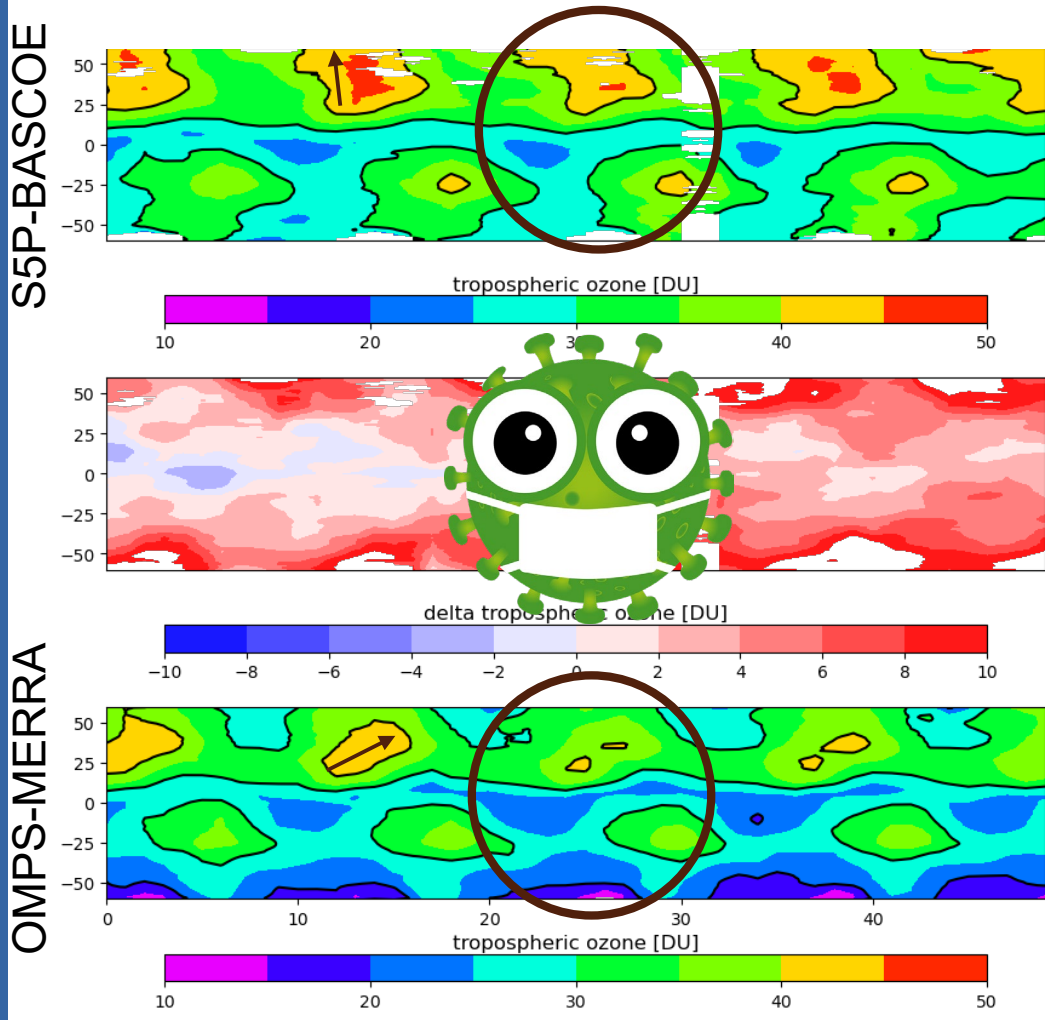


Subtract stratospheric from total column



Heue et al. 2022 10.5194/amt-15-5563-2022

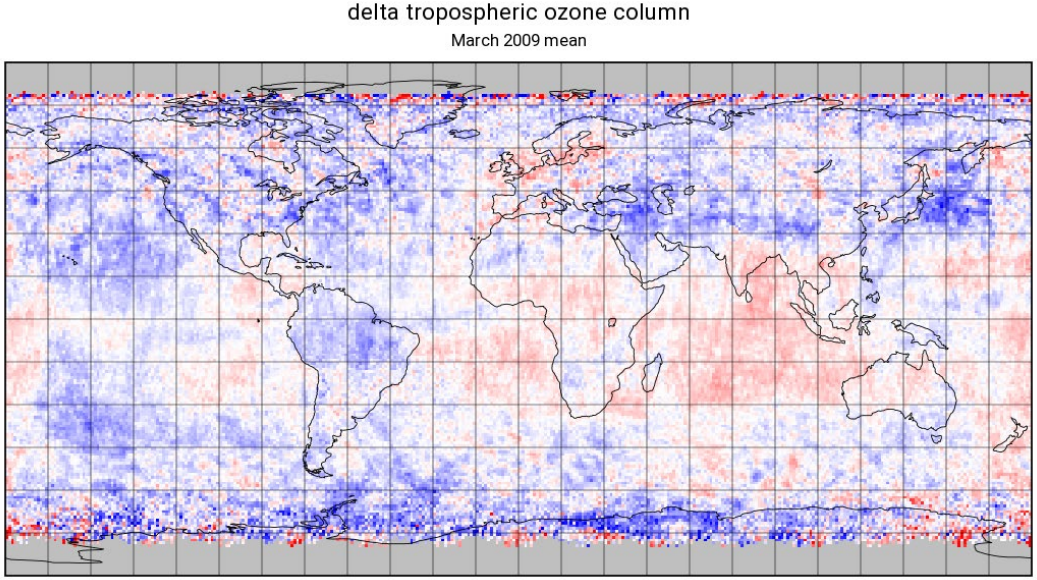
Longitudinal mean

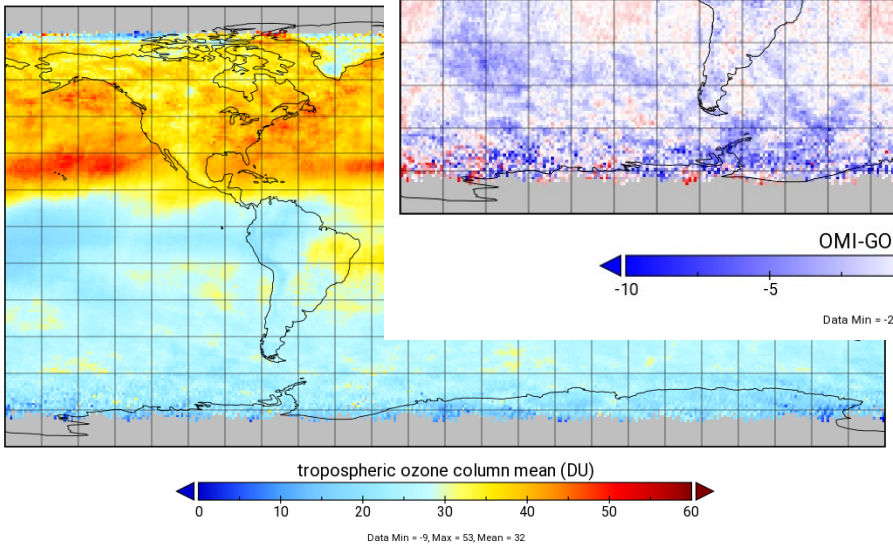


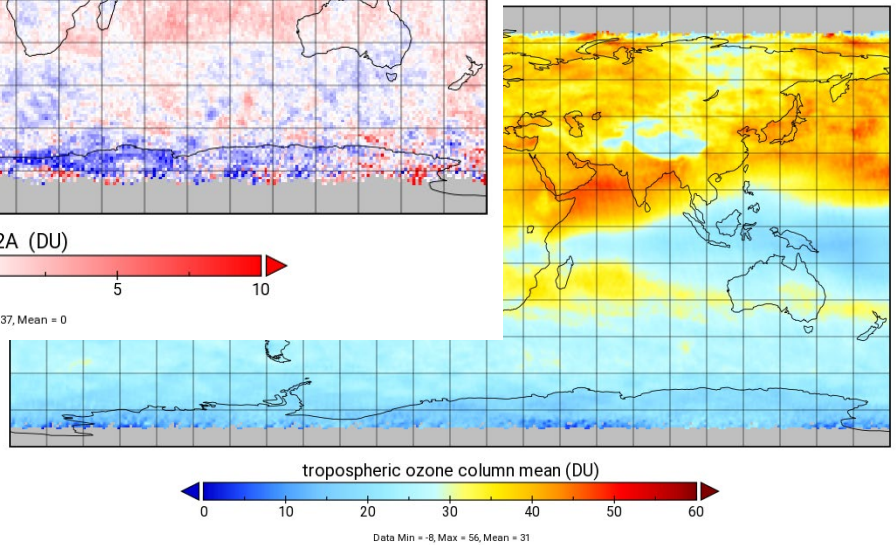
- Drift between the instruments old S5P Level-1
- Good agreement in the tropics
- Reduced tropospheric ozone in summer 2020 due to Corona lockdown
- North south development in time is tilted

Applied to GTO-ECV (first quicklooks)

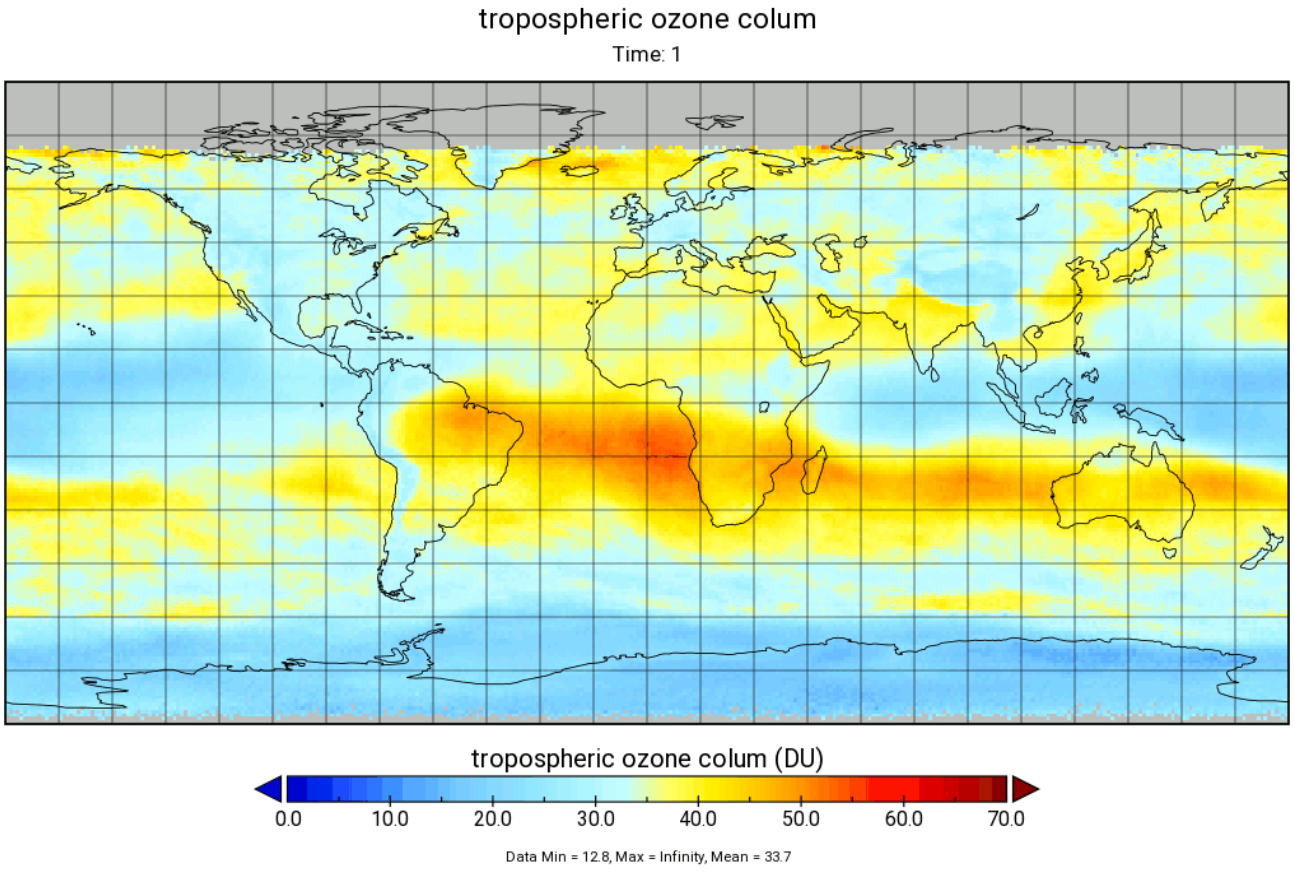
- Apply harmo… …IT dataset
- Substract B…



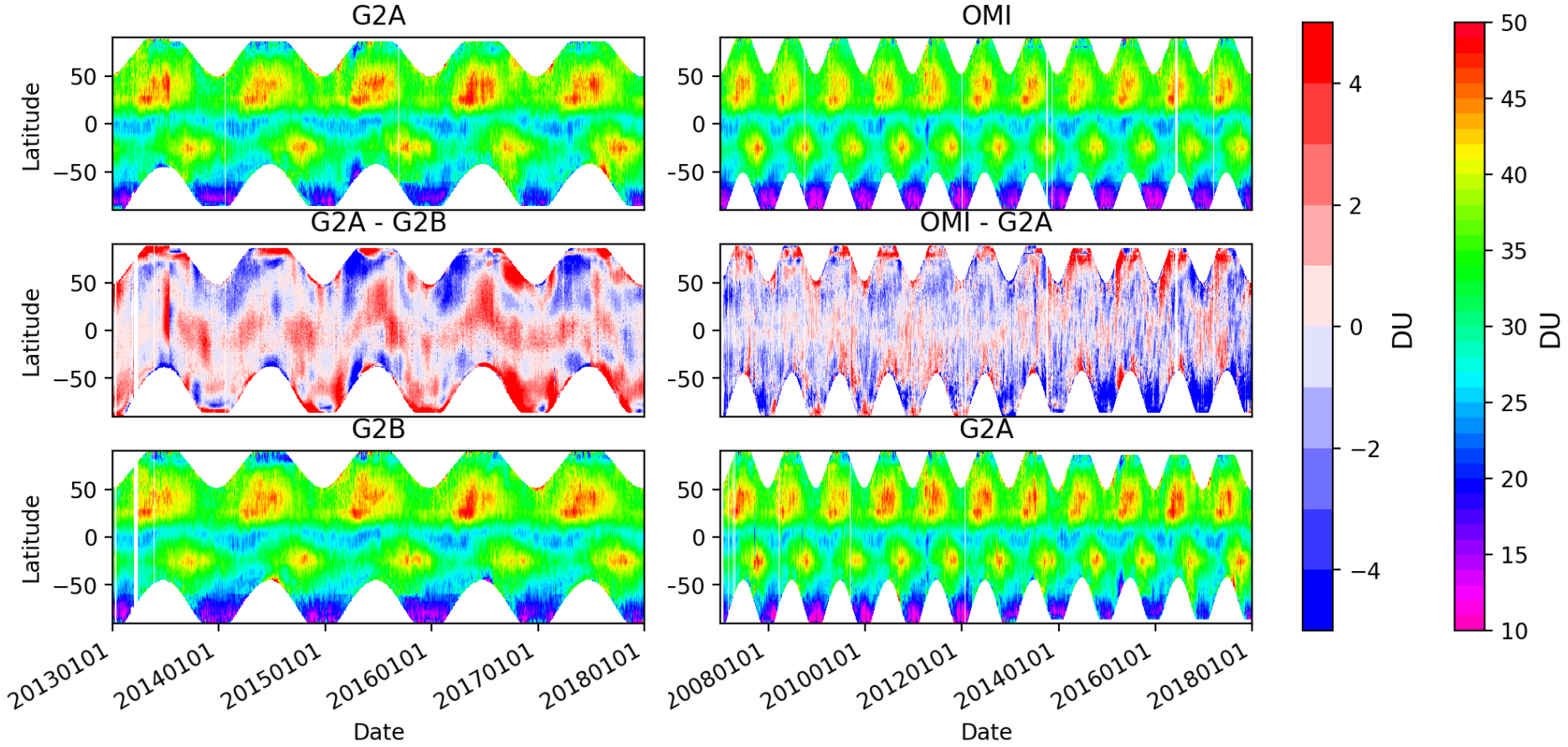




2004-2019 mean climatology



GTO-ECV internal comparisons



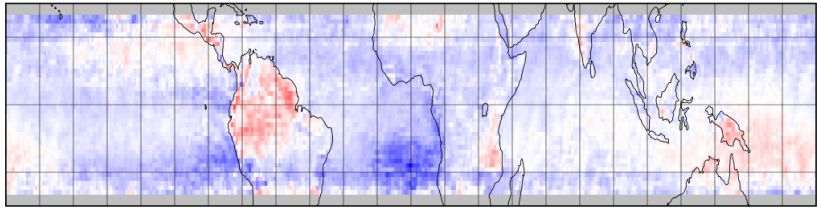
Summary S5p-BASCOE

- Global tropospheric ozone columns are retrieved from S5P-BASCOE data
- Same algorithm is currently applied to GTO-ECV

Harmonisation

- The mean difference (given in the figures) and the mean annual cycle relative OMI is subtracted/added to the measurements
- For GOME_1 the harmonized data set (SCIAMACHY) is used as reference. Due to short period of tropical overlap (one year) we use the mean difference between GOME-1 and SCIAMACHY here.

average tropospheric ozone mixingratio
(1995-2000) minus (1995-2023)

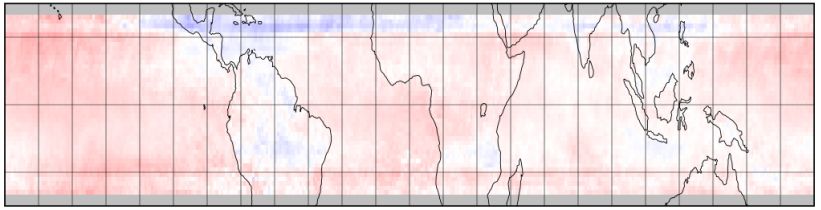


change in tropospheric ozone (ppb)

-10.0 -5.0 0.0 5.0 10.0

Data Min = -9.5, Max = 6.9

average tropospheric ozone mixingratio
(2011-2015) minus (1995-2023)

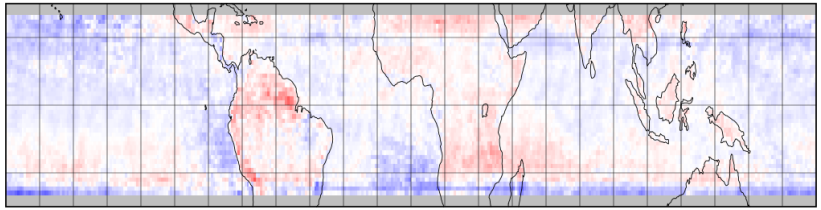


change in tropospheric ozone (ppb)

-10.0 -5.0 0.0 5.0 10.0

Data Min = -3.0, Max = 3.6

average tropospheric ozone mixingratio
(2001-2005) minus (1995-2023)

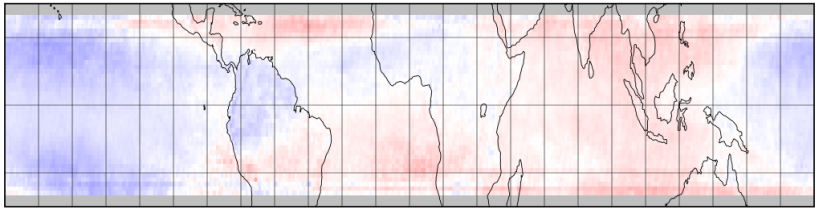


change in tropospheric ozone (ppb)

-10.0 -5.0 0.0 5.0 10.0

Data Min = -6.9, Max = 6.7

average tropospheric ozone mixingratio
(2016-2020) minus (1995-2023)

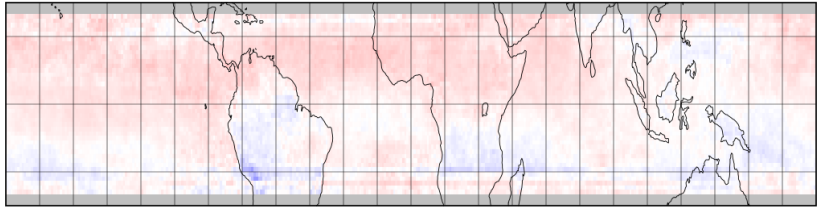


change in tropospheric ozone (ppb)

-10.0 -5.0 0.0 5.0 10.0

Data Min = -3.7, Max = 3.3

average tropospheric ozone mixingratio
(2006-2010) minus (1995-2023)

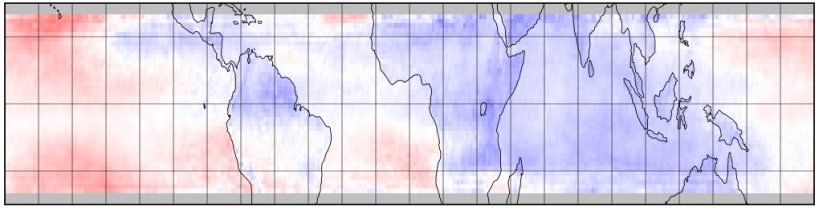


change in tropospheric ozone (ppb)

-10.0 -5.0 0.0 5.0 10.0

Data Min = -4.0, Max = 2.6

average tropospheric ozone mixingratio
(2021-jul 23) minus (1995-2023)



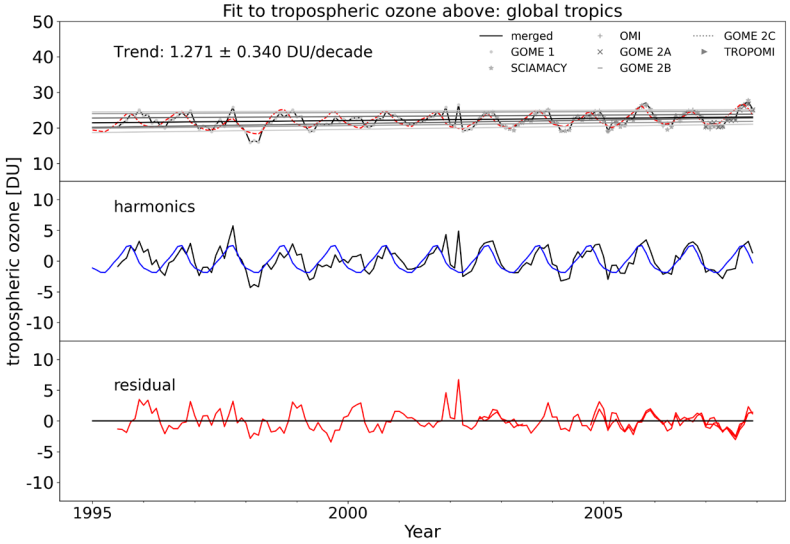
change in tropospheric ozone (ppb)

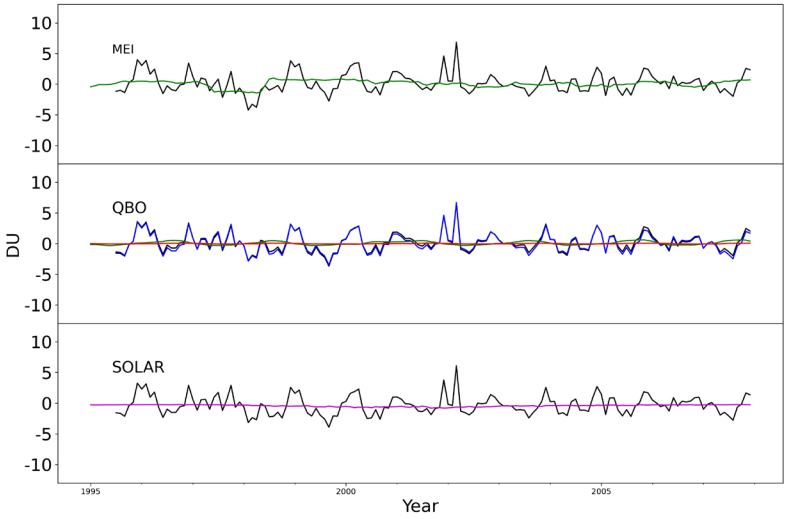
-10.0 -5.0 0.0 5.0 10.0

Data Min = -4.5, Max = 5.2

Trends 1995-2008

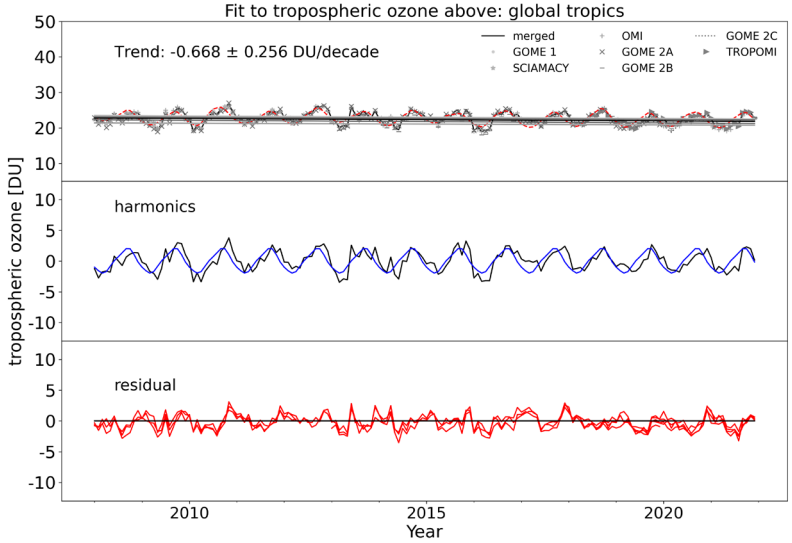
Beside the linear function a set of harmonic functions and the indices for ENSO (MEI), QBO and Solar flux were fitted.

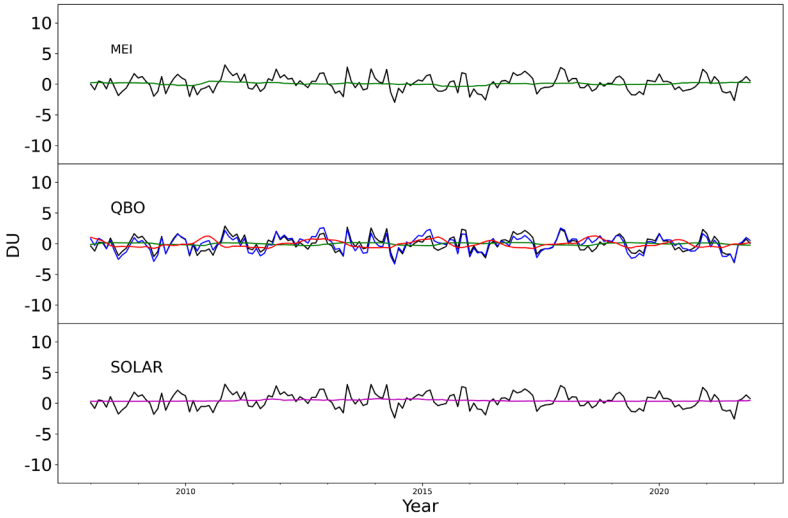




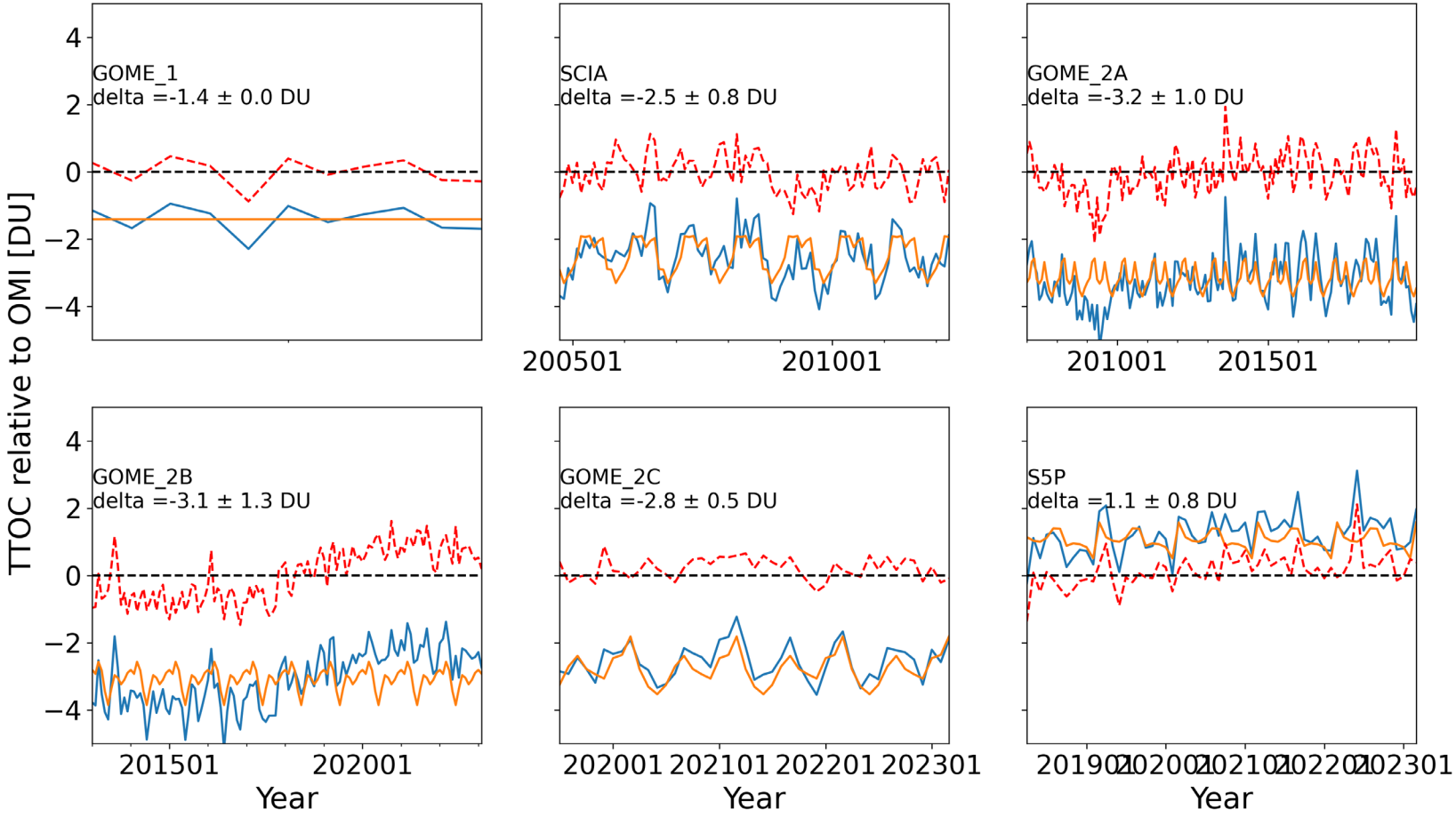
Trends 2008-2022

Beside the linear function a set of harmonic functions and the indices for ENSO (MEI), QBO and Solar flux were fitted.

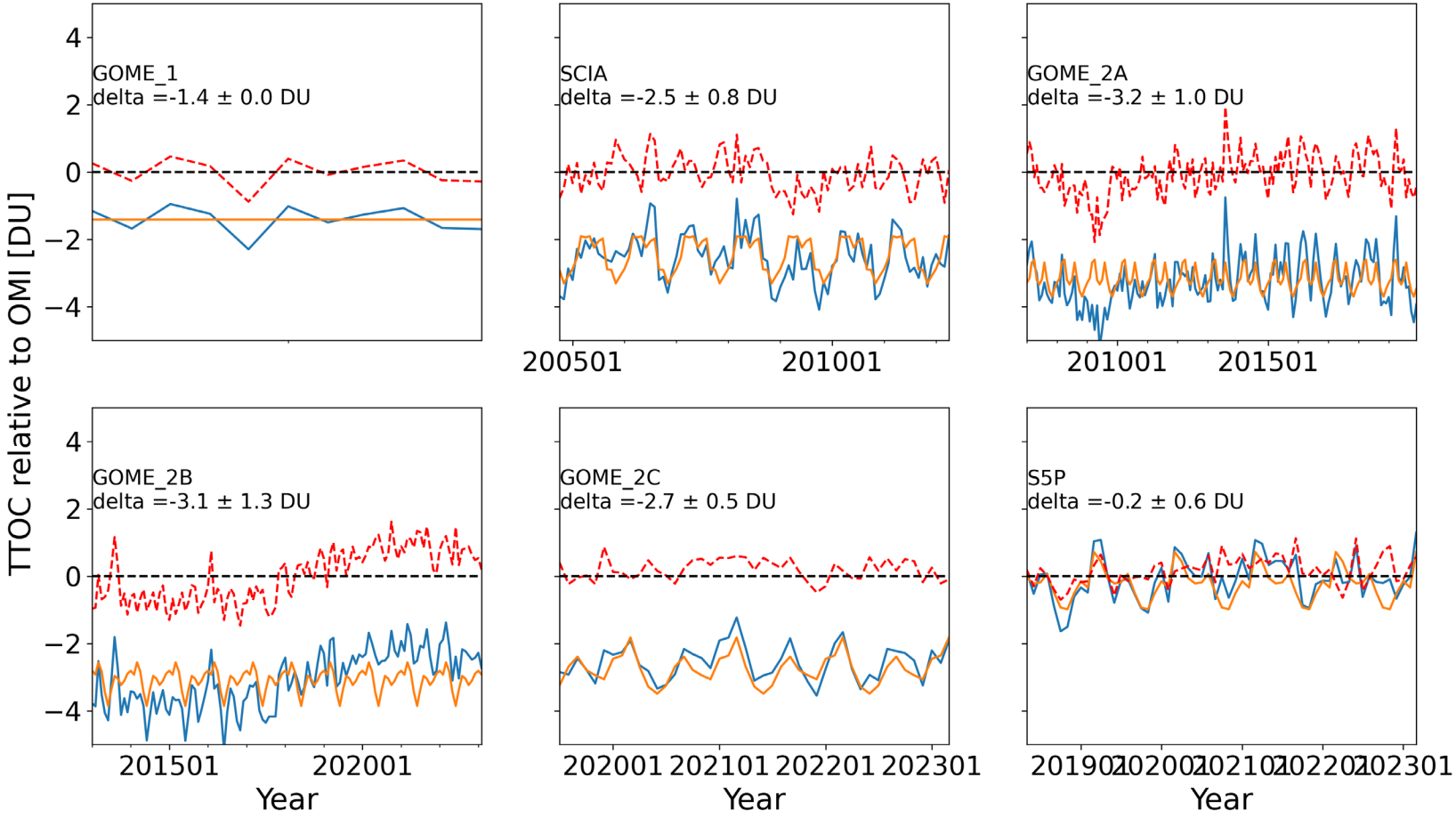




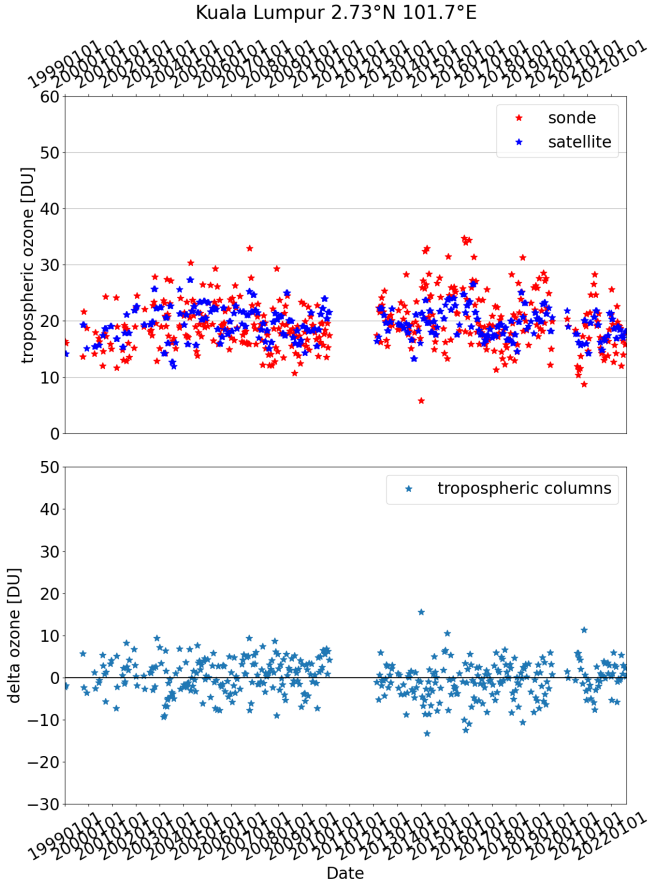
Harmonisation 270 hPa

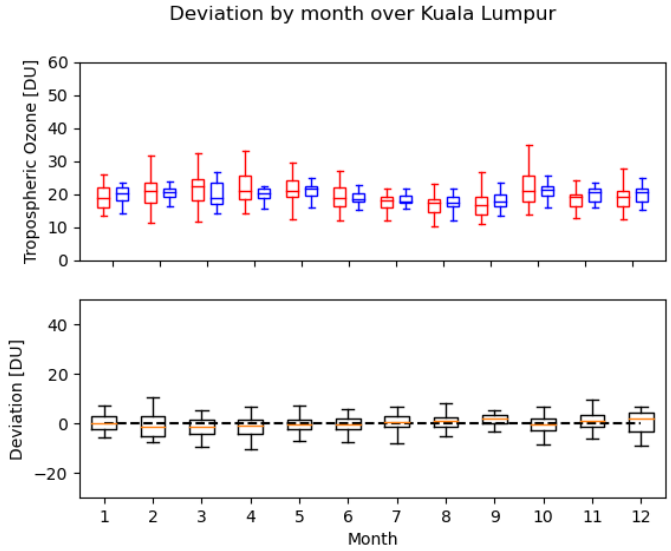


Harmonisation 200 hPa



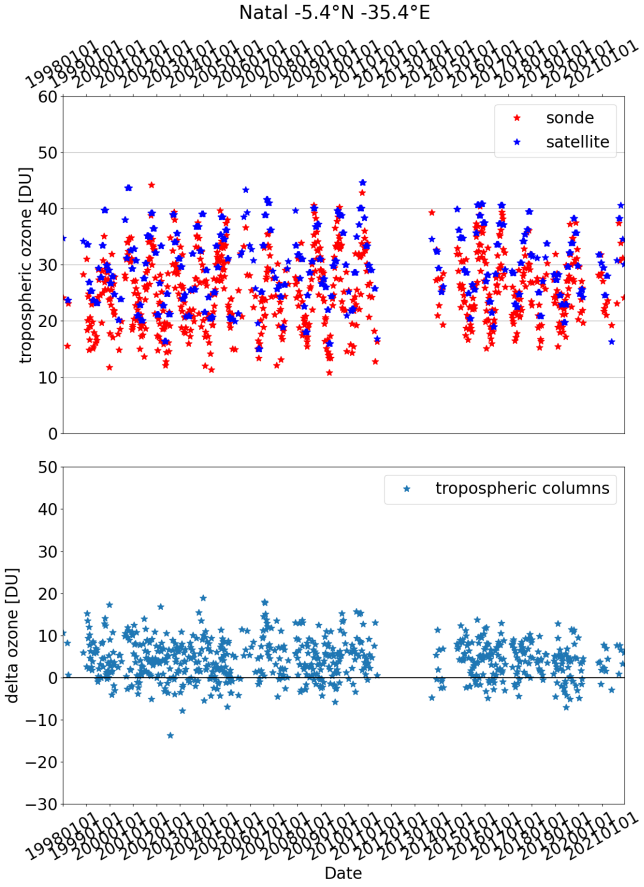
Validation Kuala Lumpur

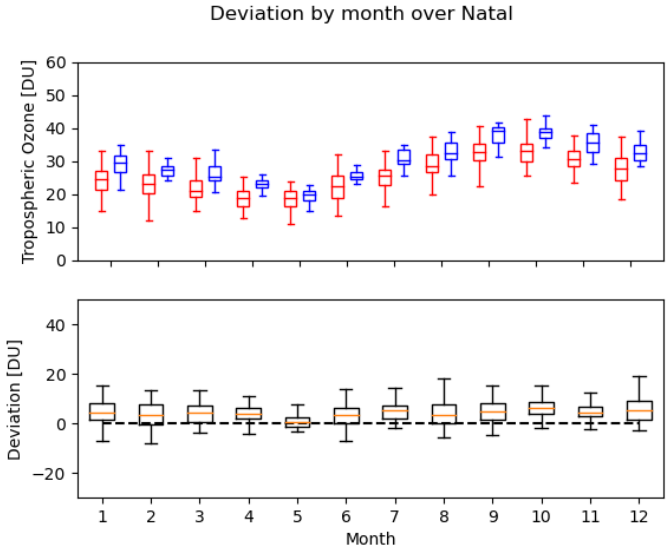




The sonde data are integrated up to 270/200 hPa and averaged over one month before comparing to the grid cell (1°x1°) that contains the sounding station

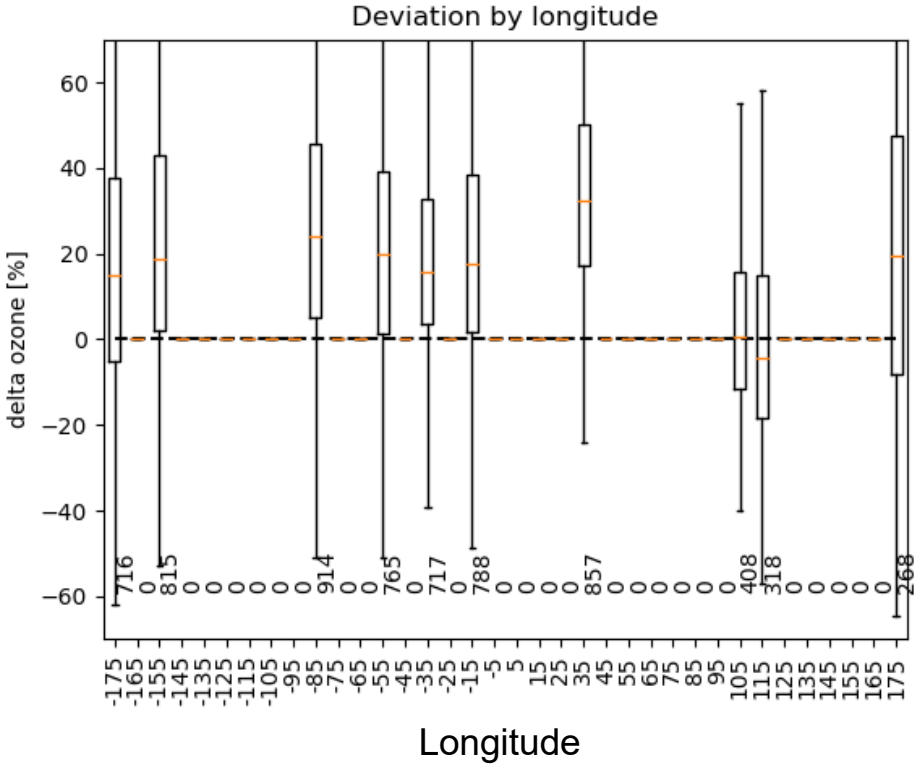
Validation Natal





very good agreement for May
Larger deviation for higher columns (Aug.-Sep.)

Validation overview



Except for the east Asian stations (Kuala Lumpur and Java) we observe a positive bias (~20%) relative to the sondes.
This finding is independent ot the CCD top level (200/270 hPa)