TROPOMI

# Tropical tropospheric ozone trends record based oon the operational TROPOMI/S5P products and the data from the precursor missions

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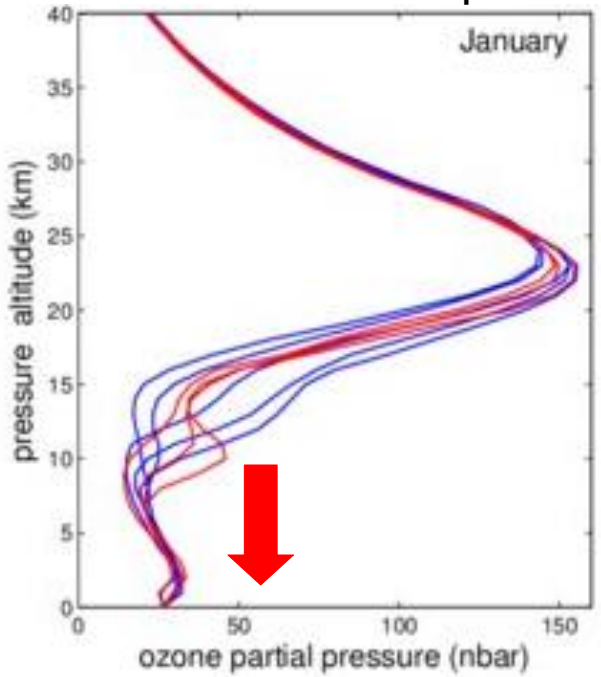
DLR TUM BIRA-IASB

# Overview

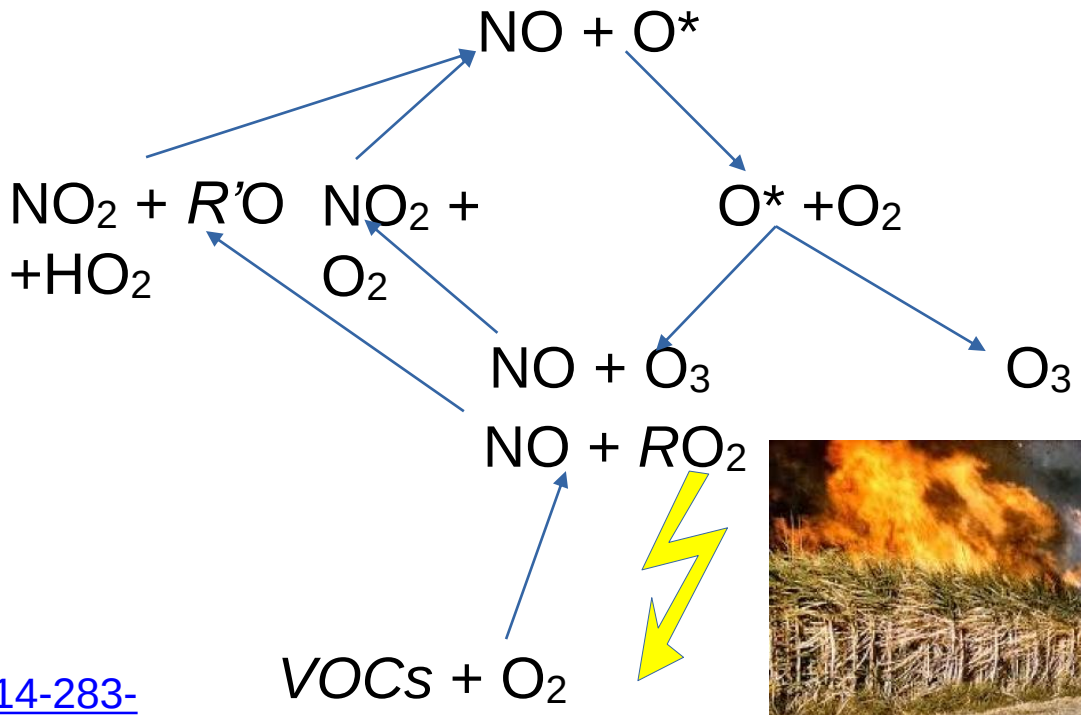
- Motivation
  - Sources of tropospheric ozone
  - Trends in Europe
- Method
  - tropical tropospheric column using CCD
  - Harmonisation of CCD
- Results
  - Trends in tropical tropospheric ozone
  - Regional trends
  - Seasonal trends

# Sources of tropospheric Ozone

Downwards transport ~10%

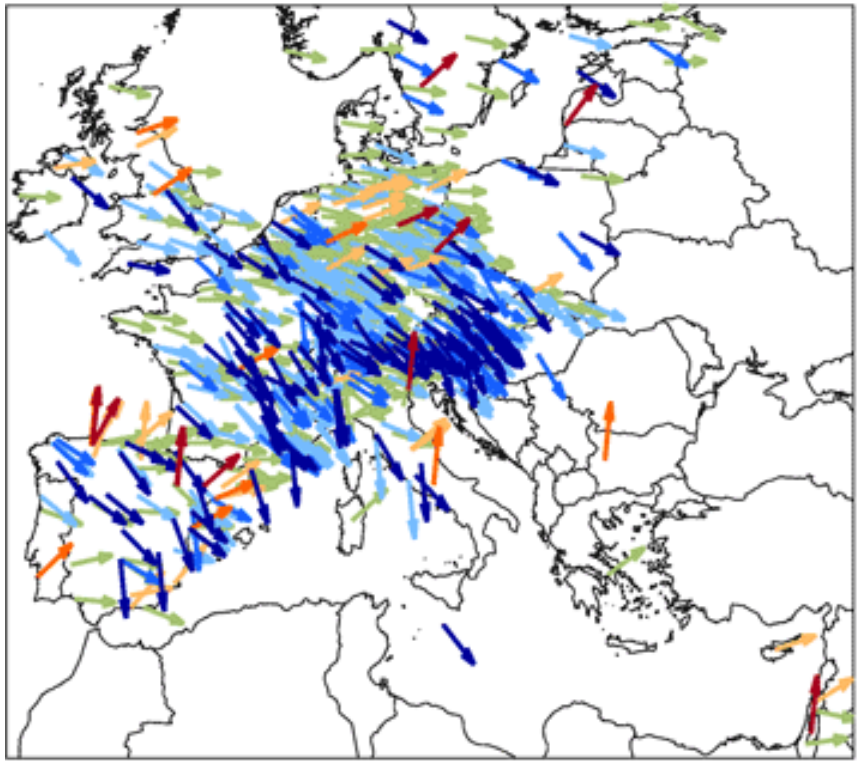



Chemical Production ~90%

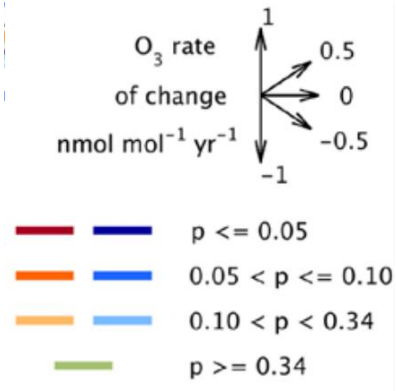





Sofieva et al. 2014 [10.5194/acp-14-283-2014](https://doi.org/10.5194/acp-14-283-2014)

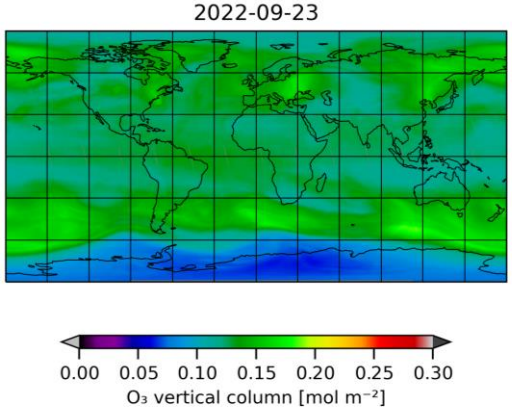


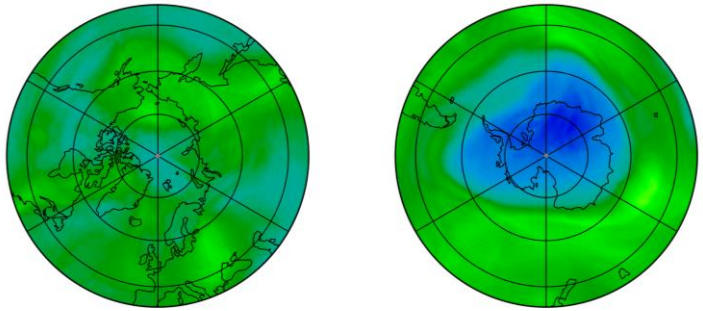
2000-2014 trends of regional daytime average ozone (nmol/(mol yr)). For June, July, August (JJA)



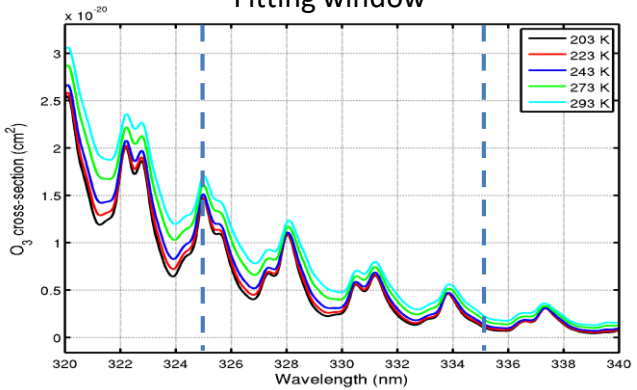

Gaudel et al. 2018
10.1525/elementa.291.f15

# Total ozone retrieval



Fitting window



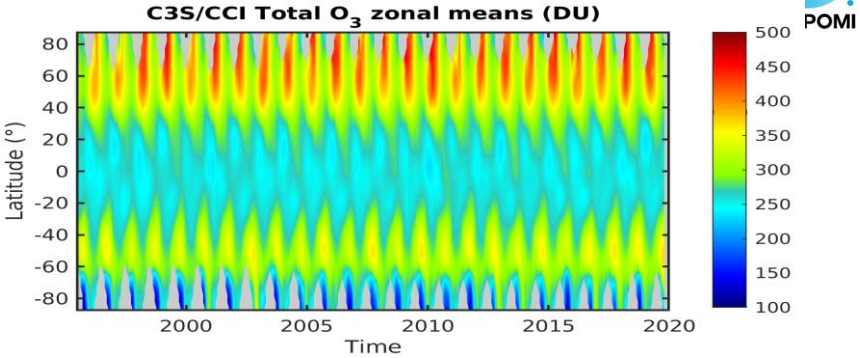

- OFFL S5P total ozone column
- Based on GOME-type Direct FITing (GODFIT -v4)
- GODFIT-v4 is also used for CS3 /CCI datasets
-

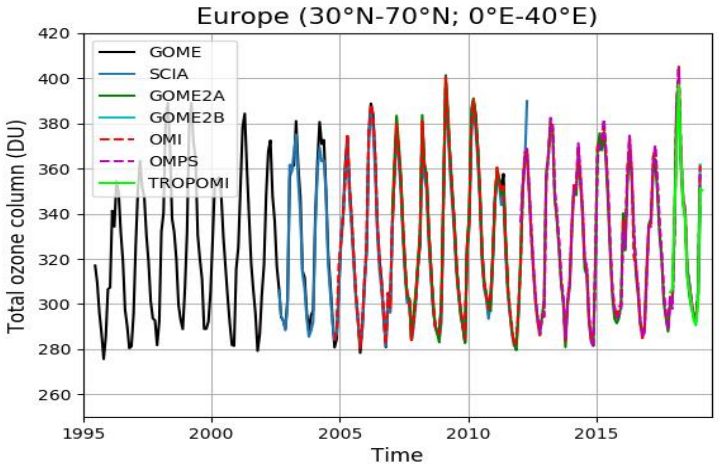
Lerot et al., 2014
10.1002/2013JD020831

http://mpc-l2.tropomi.eu/#

# Long-term climate TO3 record

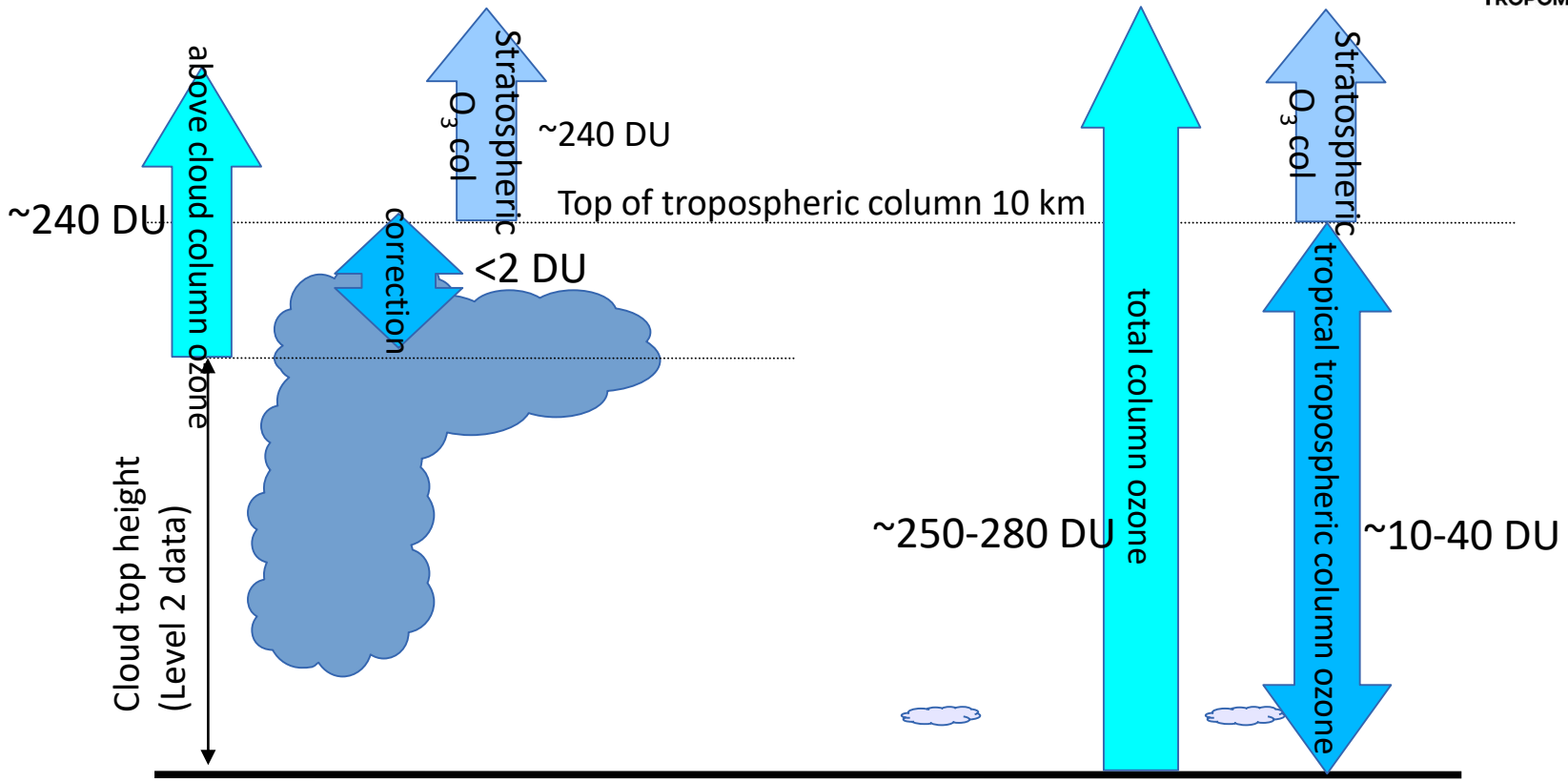
- Retrieval algorithm applied consistently to many different sensors, which, cover a period of 26 years of TO3 measurements from space.



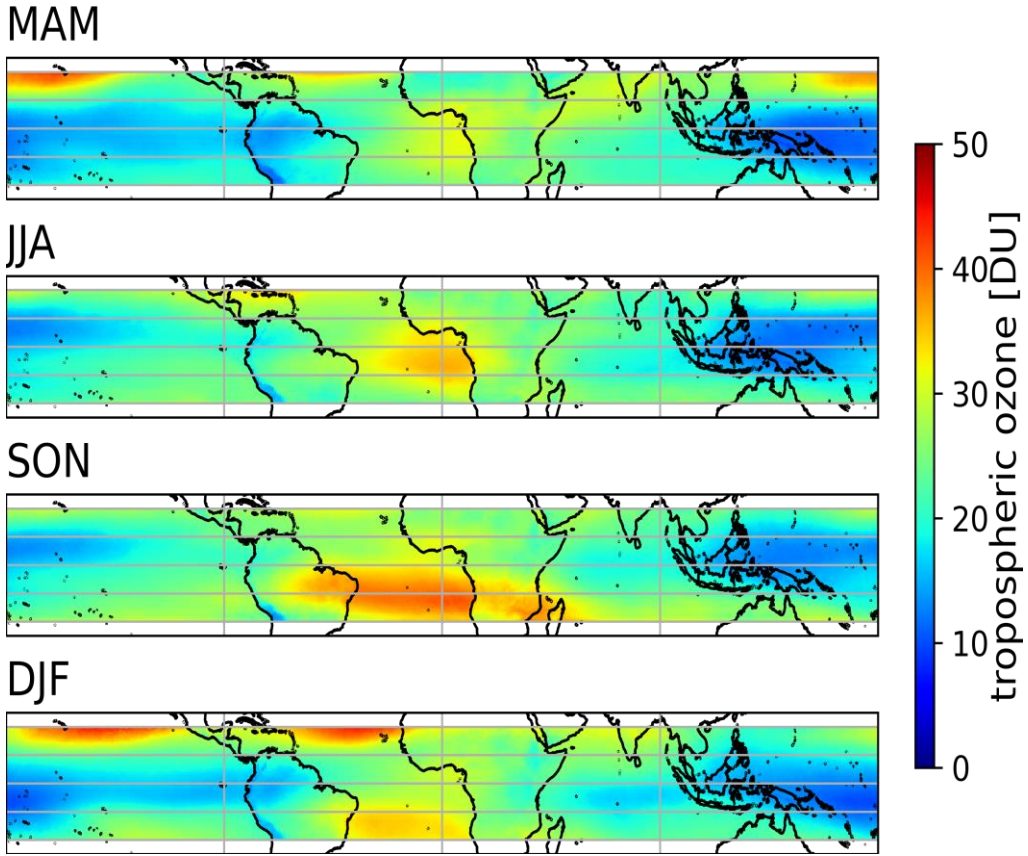




| | |
|---|---|
| GOME/ERS-2 | Jun 95 – Jun 11 |
| SCIAMACHY/Envisat | Aug 02 – Mar 12 |
| OMI/Aura | Oct 04 – present |
| GOME-2/Metop-A | Jan 07 – Nov 21 |
| GOME-2/Metop-B | Jan 13 – present |
| GOME-2/Metop-C | Jul 19 – present |
| OMPS/Suomi-NPP | Jan 12 – present |
| TROPOMI/S5p | May 18 – present |

# Convective cloud differential (CCD)



# Example data S5P seasonal means 2018 - 2022

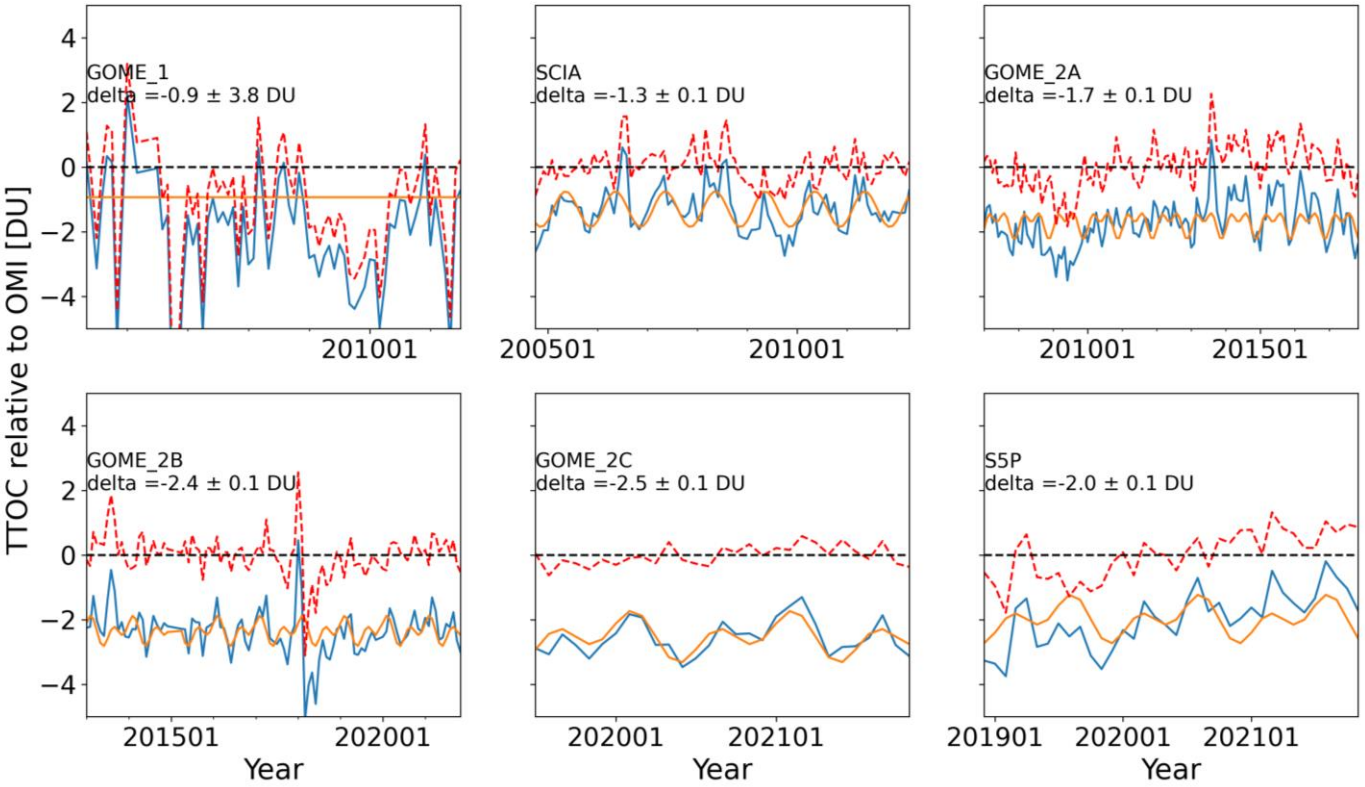



The assumption that the stratospheric column is constant for a view days and along the longitude limits the data to the tropics

# Available data sets overview

| | GOME | SCIAMACHY | GOME_2 (A,B,C) | OMI | TROPOMI | |
|---|---|---|---|---|---|---|
| period | 1995 - 2011 | 2002 - 2012 | 2007-2017<br>2013-today<br>2019-today | 2004-today | 2018 -today | |
| CCD | Monthly<br>1.25° x 2.5° | | | | 3 days<br>0.5° x 1° | Monthly<br>1.25° x 2.5° |
| CCD harmonised | OMI as Reference merged data set 1995 – 2021<br>monthly 1.25 x 2.5° | | | | | |

# Harmonisation




Comparison of tropical mean to OMI or merged data and correction of

- Bias
- Seasonal pattern (sine,cosine combination)

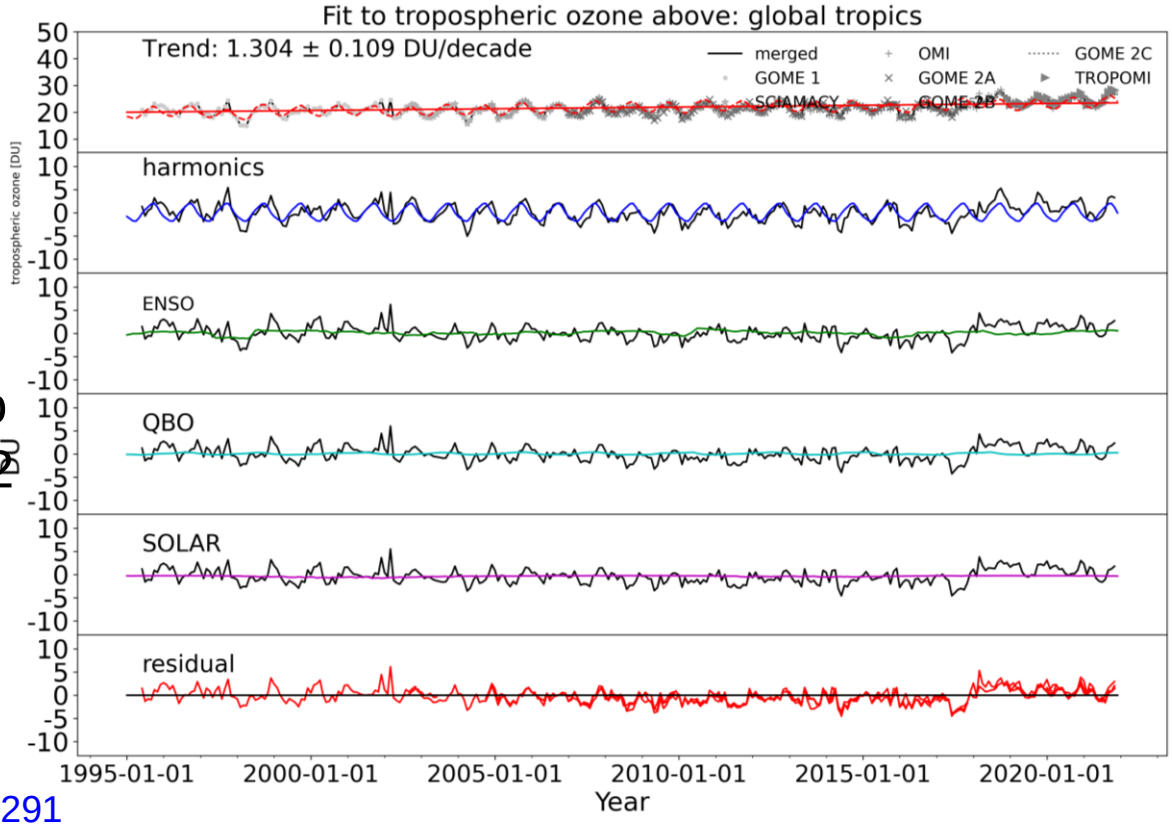
correction(time) added to monthly data
Individual sensors averaged to merged data product

Method described in Heue et al. 2016 AMT

# Results mean tropical trend

Mean tropical tropospheric ozone increases by ~1.3 DU/decade

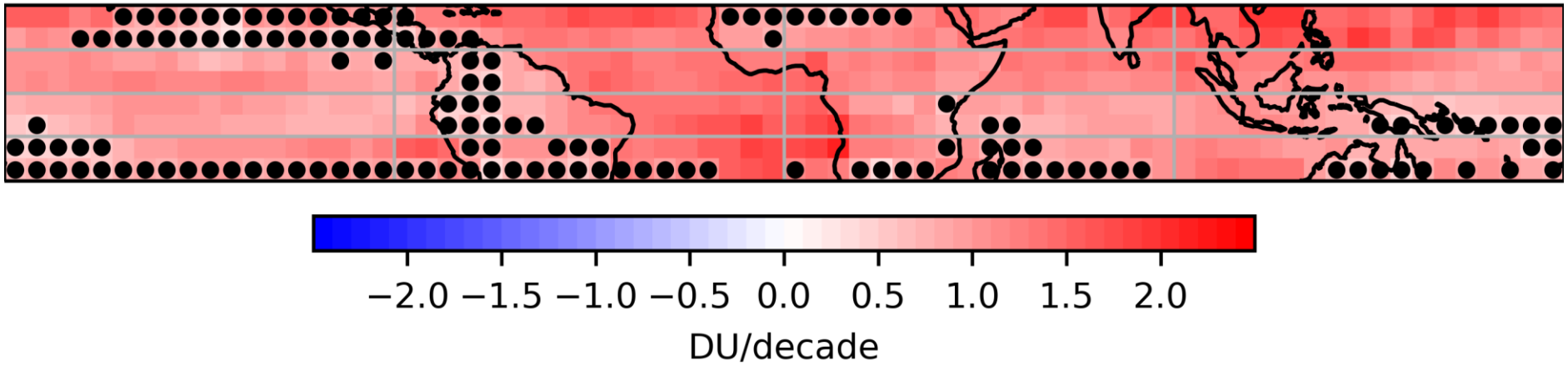
Other satellite retrievals result* in trends of 0.9 up to 5 DU/decade mostly about 2 DU/decade




* Gaudel et al 2018: [10.1525/elementa.291](https://doi.org/10.1525/elementa.291)

# Regional trends

trend in tropospheric column ozone




- Dots indicate insignificant trends
- No decreasing trend is observed
- Strongest trend over southern Atlantic / African coast

# Seasonal trends

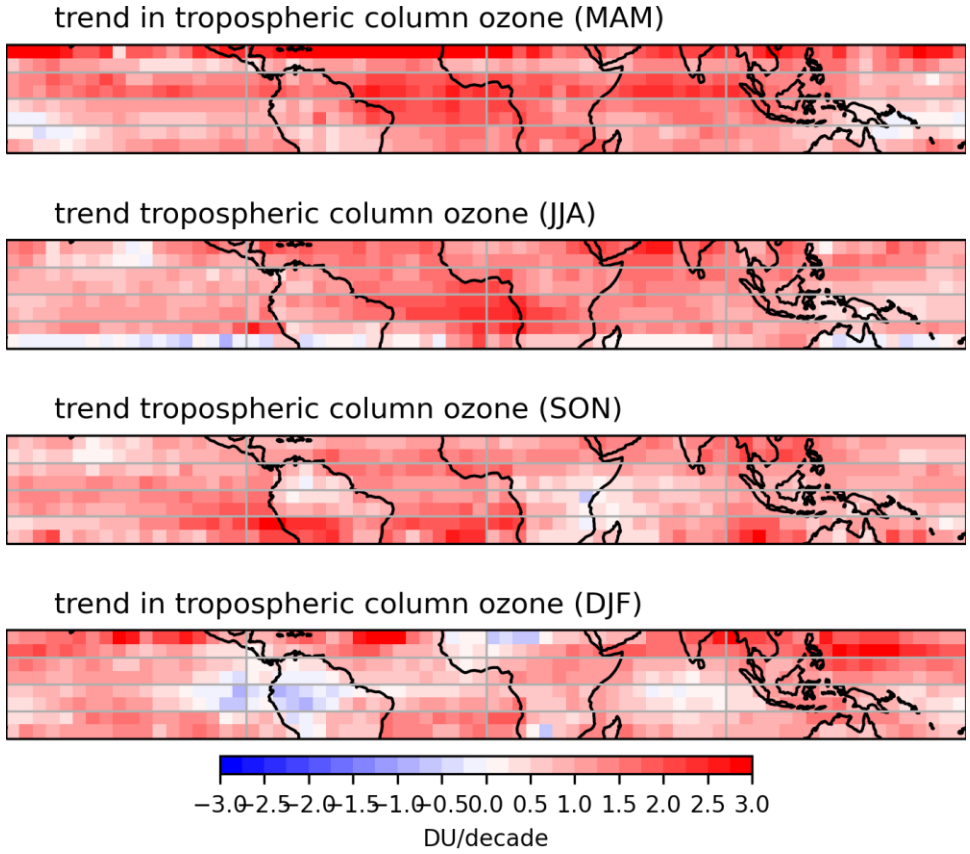
tropical increase in DU/decade for:

Spring 0.55 ± 0.65

Summer 0.30 ± 0.7

Autumn 0.81 ± 0.77

Winter 0.24 ± 0.71



# Conclusion Outlook

Based on the CCD data set from 1995 to 2021 we derived a mean tropical trend of 1.3 DU/decade in the tropospheric ozone data

The trends show spatial and temporal variation

The highest trend is observed over African Atlantic coast

Only in the Dec to Feb season a decreasing trend is found

# Acknowledgment

Thank to all ozone sounding station for providing the data to WOUDC (Environment Canada) and SHADOZ

Thank to WOUDC and to SHADOZ for the service of providing the data to all users

# Outlook

S5P:

- include CSA in operational product
- Use cloud slicing mixing ratio for correction term

CCI Trends:

- continue data set
- increase resolution to 1° x 1°
- Will be part of $O_3$ CCI+
- Change correction function to monthly mean deviation