Ozone trends in the stratosphere derived using merged Ozone_CCI datasets

ESA Climate Change Initiative: Ozone

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LONG-TERM OZONE TRENDS AND UNCERTAINTIES IN THE STRATOSPHERE
LOTUS

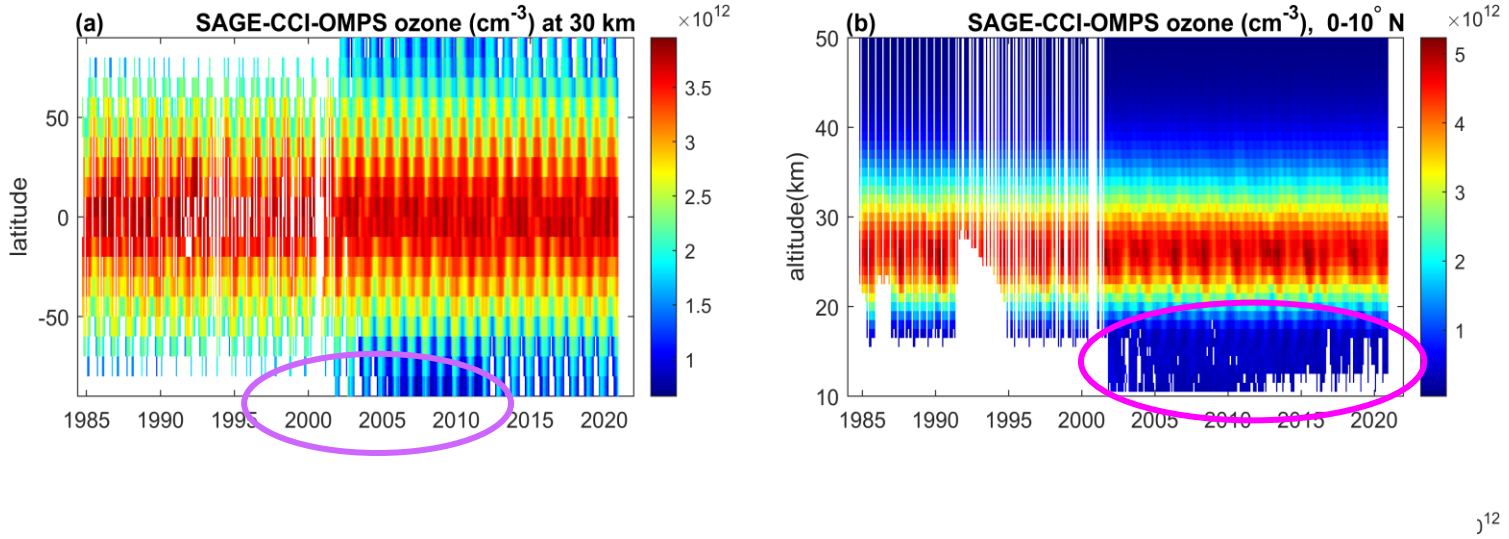
OREGANO

Ozone_CCI long-term datasets

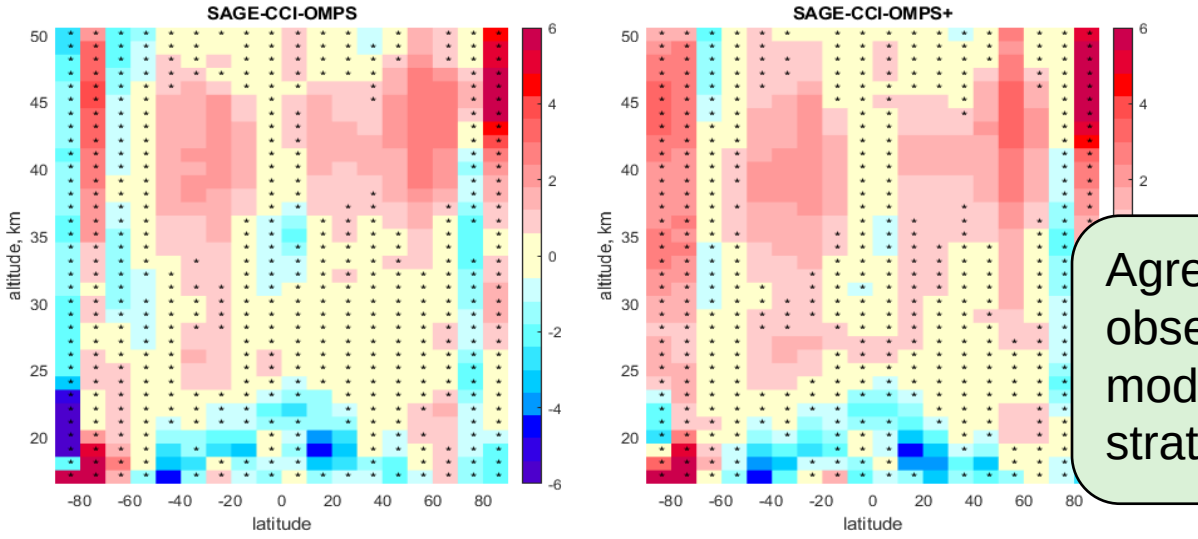
- SAGE-CCI-OMPS+
  - 10° latitude x month, since 1984
- MErged GRIdded Dataset of Ozone Profiles (MEGRIDOP)
  - 10° latitude x 20 ° longitude x month, since 2001
- High-resolution dataset of ozone profiles (LIMB-HIRES)
  - 1° x 1° x 1 day, since 2004

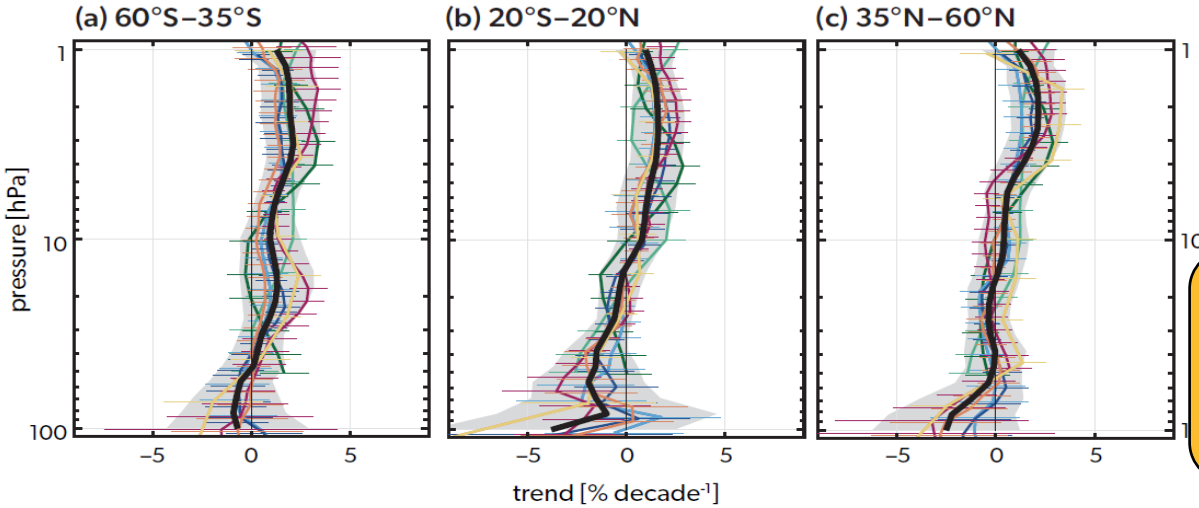
From SAGE-CCI-OMPS to SAGE-CCI-OMPS+

- Original version SAGE-CCI-OMPS:
  - 7 instruments: SAGE II, OSIRIS, GOMOS, MIPAS, SCIAMACHY, ACE-FTS, OMPS-LP (USask)
- SAGE-CCI-OMPS+ dataset
  - New versions of datasets from
    - MIPAS (v8)
    - ACE-FTS (v4.1/4.2)
    - OSIRIS v7
  - OMPS-LP: both Usask and UBr data
  - New instruments
    - SAGE III/ISS
    - POAM III
- Better coverage of polar regions
- Better coverage of the UTLS



Evaluation of ozone trends in the stratosphere

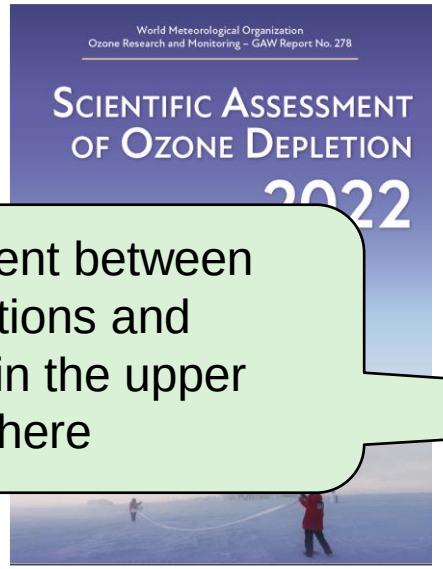




Individual datasets
- SBUV NASA (MOD)
- SBUV NOAA (COH)
- GOZCARDS
- SWOOSH
- SAGE-OSIRIS-OMPS
- SAGE-CCI-OMPS
- SAGE-SCIAMACHY-OMPS

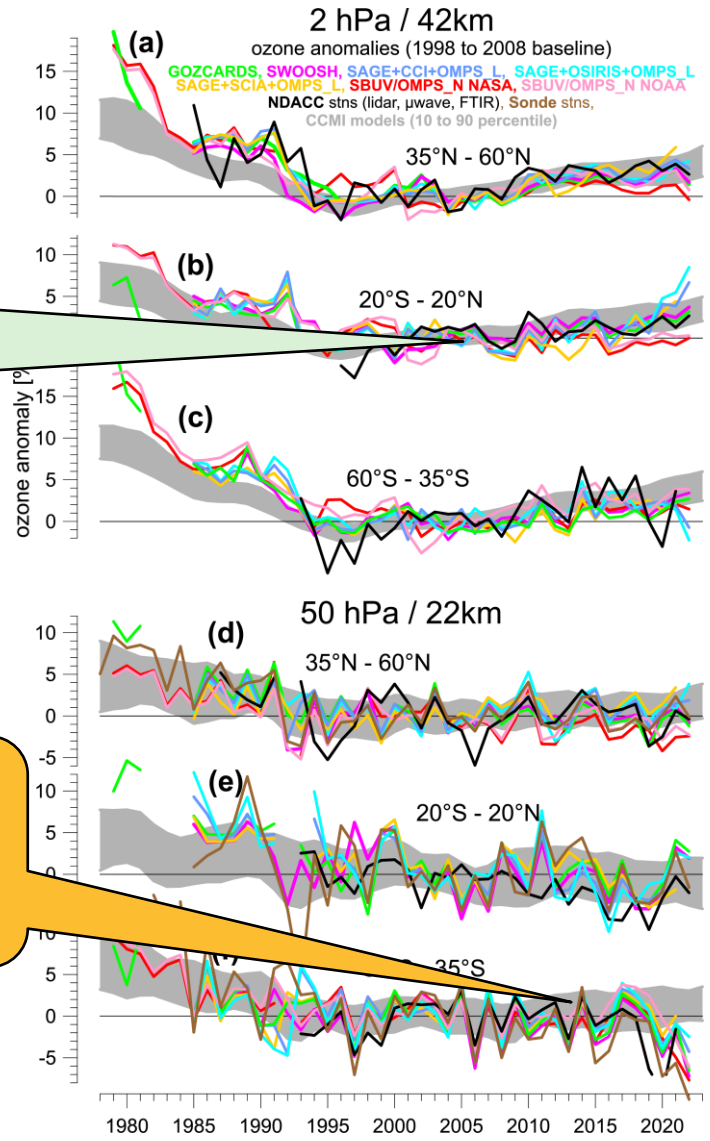
Combined (mean) trend
2σ

Post-2000 trends in %/dec



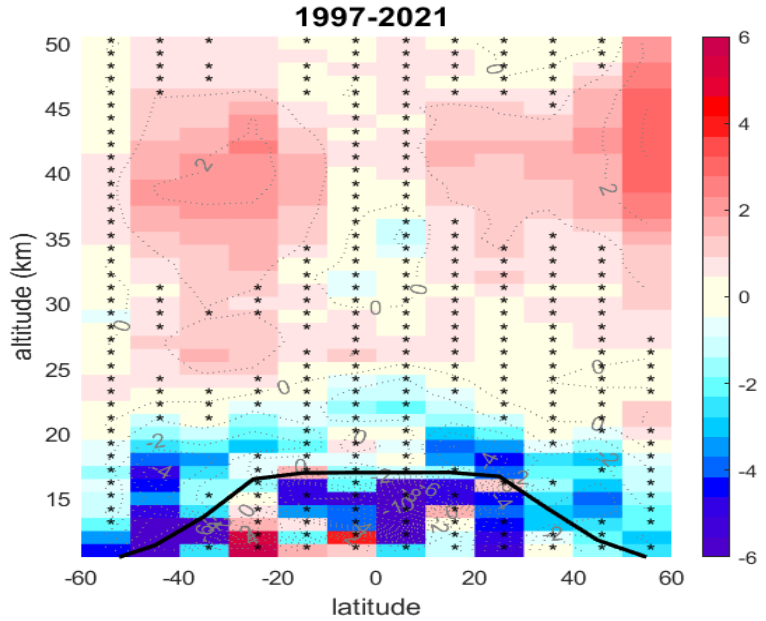
Agreement between observations and models in the upper stratosphere

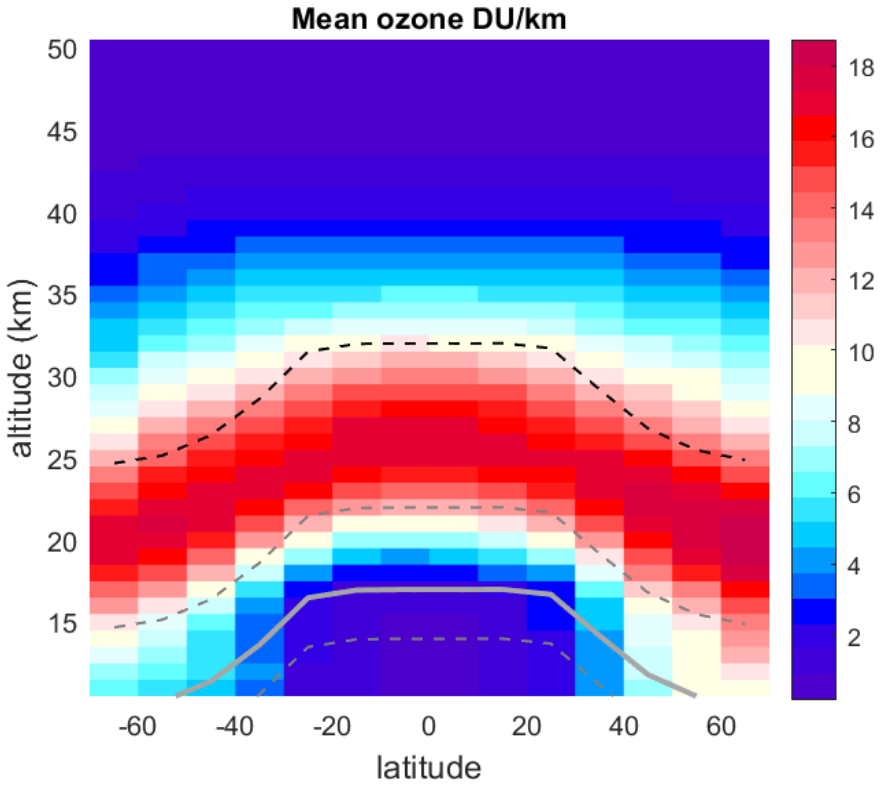
Disagreement in the lower stratosphere

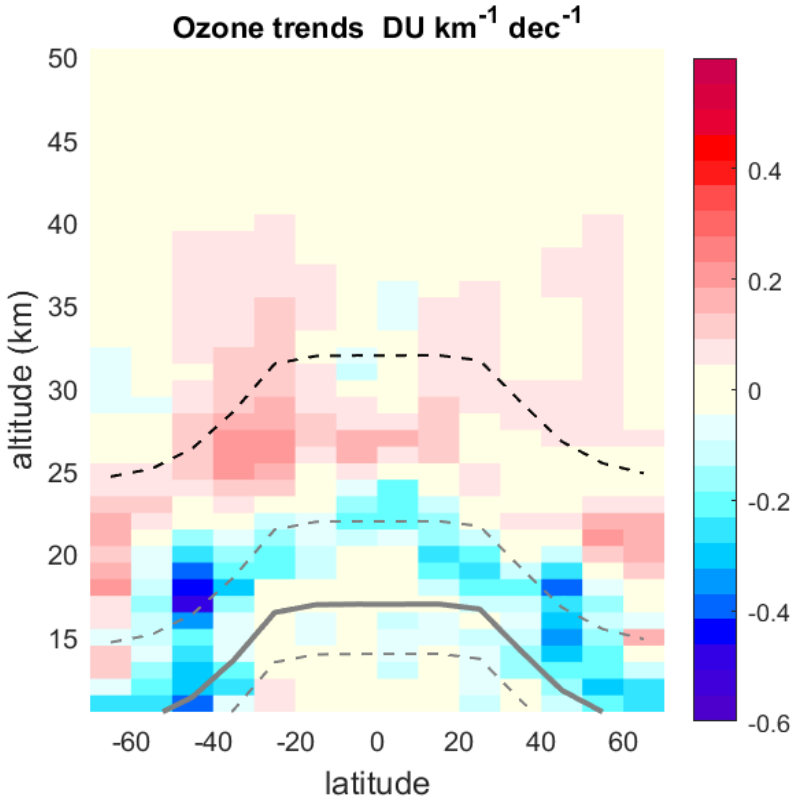


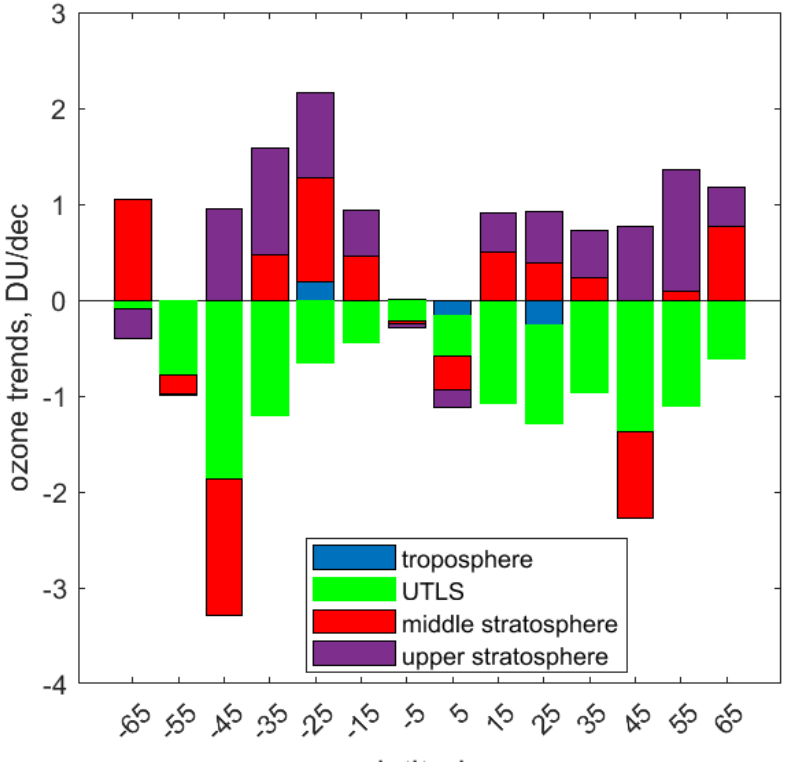
Ozone trends in partial columns

Ozone trends in % dec-1

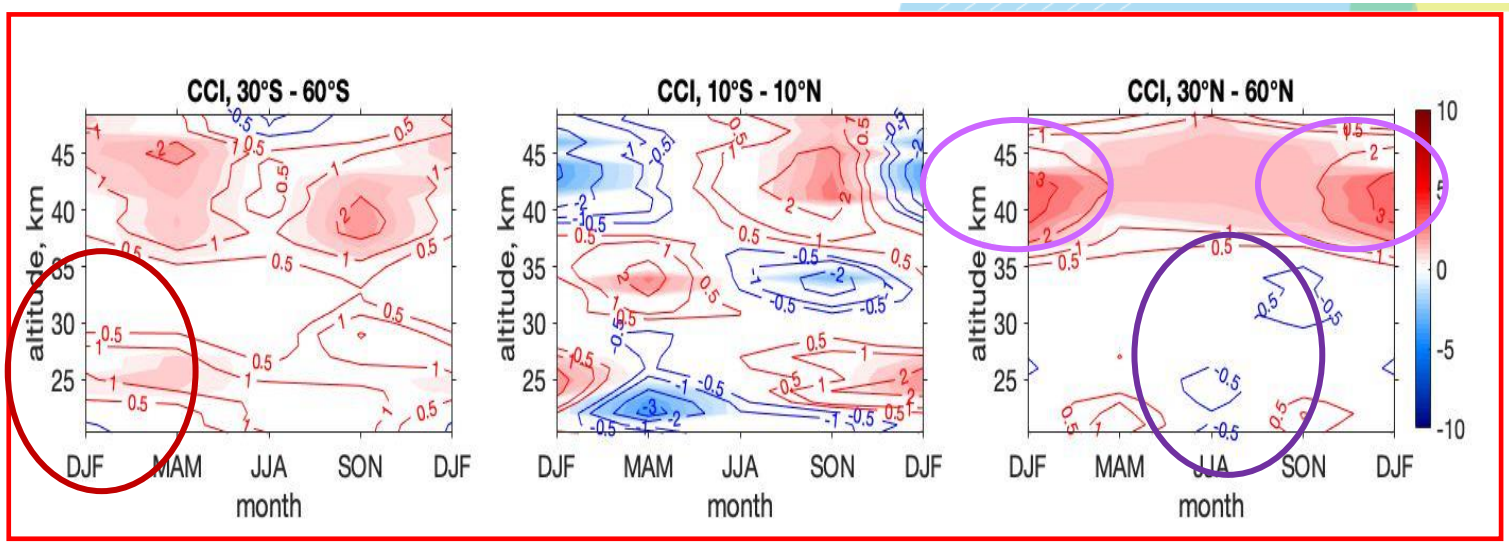


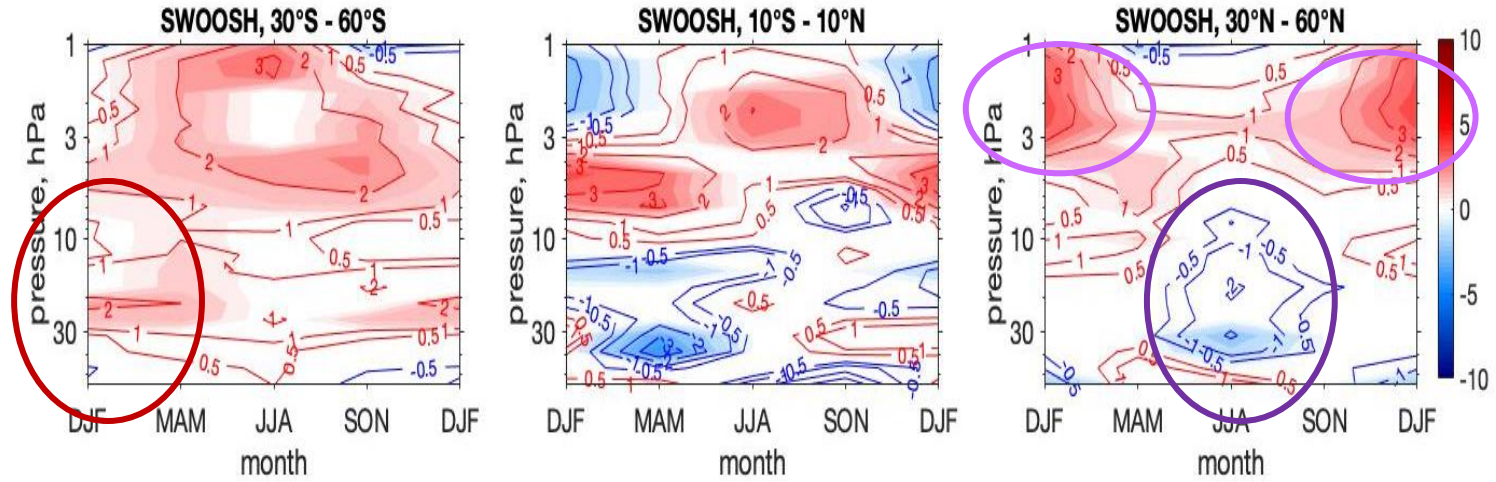






Seasonal dependence of ozone trends



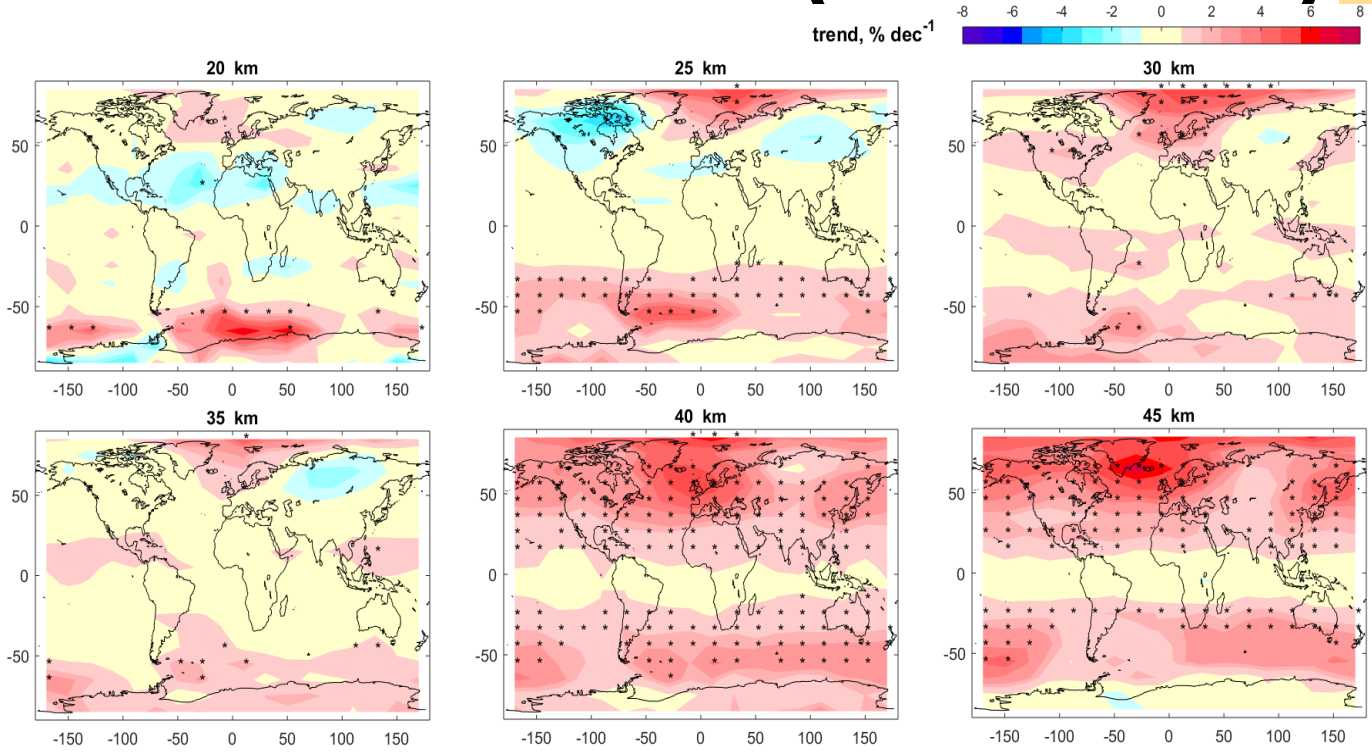


- Different merged data sets show very similar results
- The upper stratospheric ozone is recovering, and the trends are larger during local winters
- In the tropics, there is very strong seasonal dependence of ozone trends at all altitudes. The trends are changing from positive to negative, depending on altitude and season.
- In the lower/middle stratosphere, there is hemispheric asymmetry during the local summers at mid-latitudes with negative trend in the North and positive trend in the South.

- *Adapted from Szelag et al., 2020*
- *trends in % per decade.*
- *statistically significant trends at 95 % confidence level are shaded (red, blue)*

Merged GRIdded Dataset of Ozone Profiles (MEGRIDOP)

- Combined data from 6 limb-viewing satellite instruments: MIPAS, SCIAMACHY, GOMOS, OSIRIS, OMPS-LP, MLS
- The monthly means in 10°x20 ° latitude-longitude bins and altitudes 10-50 km, it covers years 2001-present
- The dataset is in open access: https://climate.esa.int/en/projects/ozone/data/



More details:
Sofieva et al: Measurement report: regional trends of stratospheric ozone evaluated using the MErged GRIdded Dataset of Ozone Profiles (MEGRIDOP), Atmos. Chem. Phys., 21, 6707–6720, https://doi.org/10.5194/acp-21-6707-2021, 2021

- Statistically significant trends in the upper stratosphere are observed.
- A longitudinal structure is clearly visible in the NH mid-latitude trends above 25 km: the trends are significantly larger over Scandinavia/Atlantic ocean (5-6 % dec^{-1}) than over Siberia (~1 %dec^{-1}).
- Positive statistically significant trends (1-2 % dec^{-1}) are observed also at SH mid-latitudes (~40°-50°S) at 25 km.
- The first attempt to evaluate ozone trends in polar regions

High-resolution dataset of ozone profiles: LIMB-HIRES

- 1° x 1° x 1 day
- since (2002) 2004
- Original development: the ESA SUNLIT project
- Ozone profile datasets
  - MLS, GOMOS, MIPAS, SCIAMACHY, OSIRIS, OMPS-LP, ACE-FTS, SAGE III/ISS

Homogenization of ozone profile data from the limb satellites

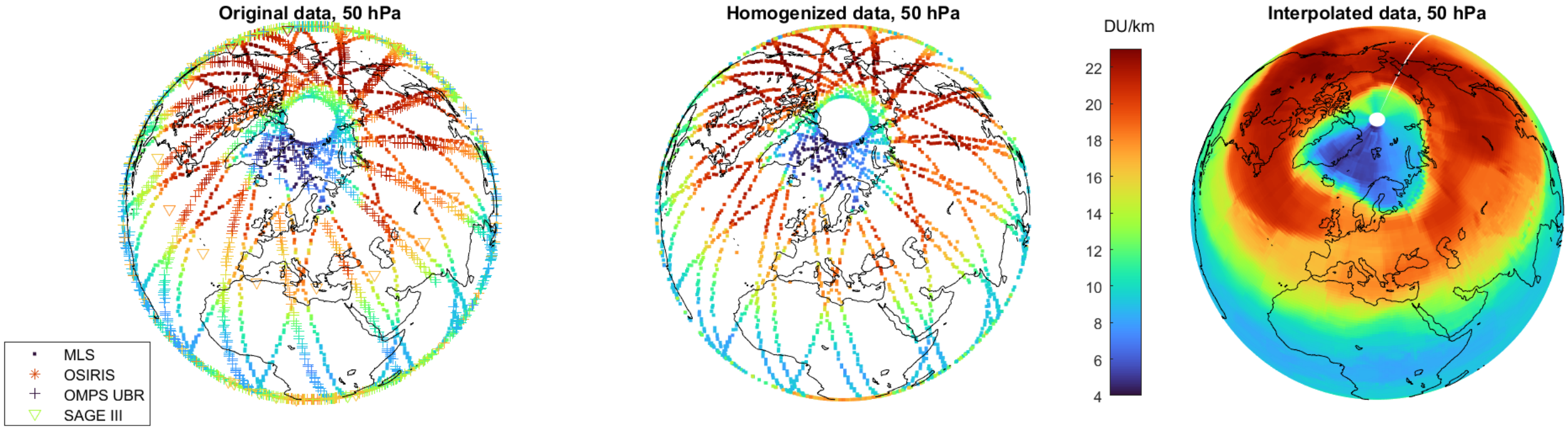
Interpolation of the limb profiles from each day to 1°x1° horizonal grid

A smooth transition to the adjusted model data below the tropopause

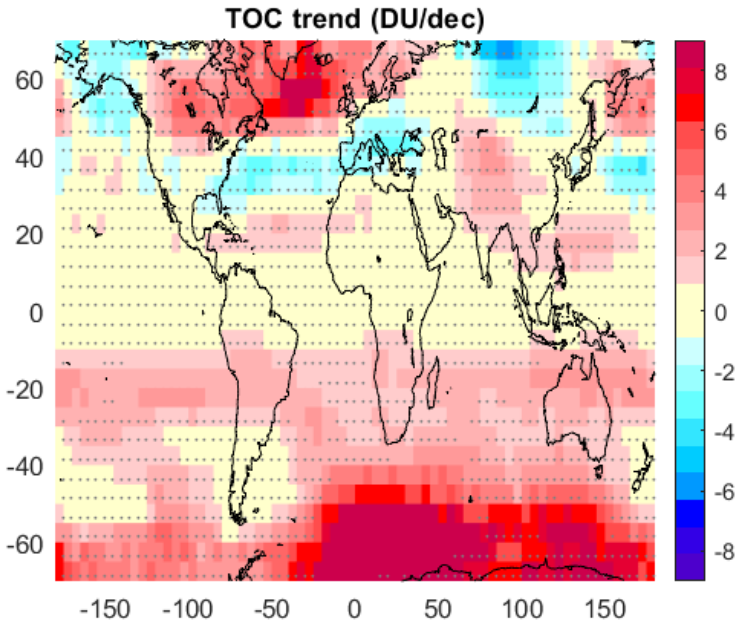
Sofieva et al: Synergy of Using Nadir and Limb Instruments for Tropospheric Ozone Monitoring (SUNLIT), Atmos. Meas. Tech., 15, 3193–3212, https://doi.org/10.5194/amt-15-3193-2022, 2022

High-resolution interpolated dataset: visualization of extreme events

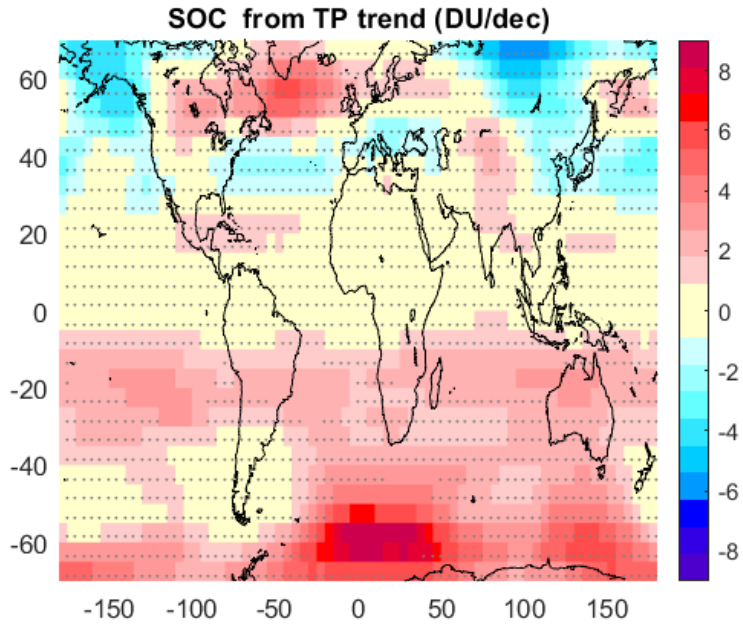
Arctic ozone hole 6 Apr 2020



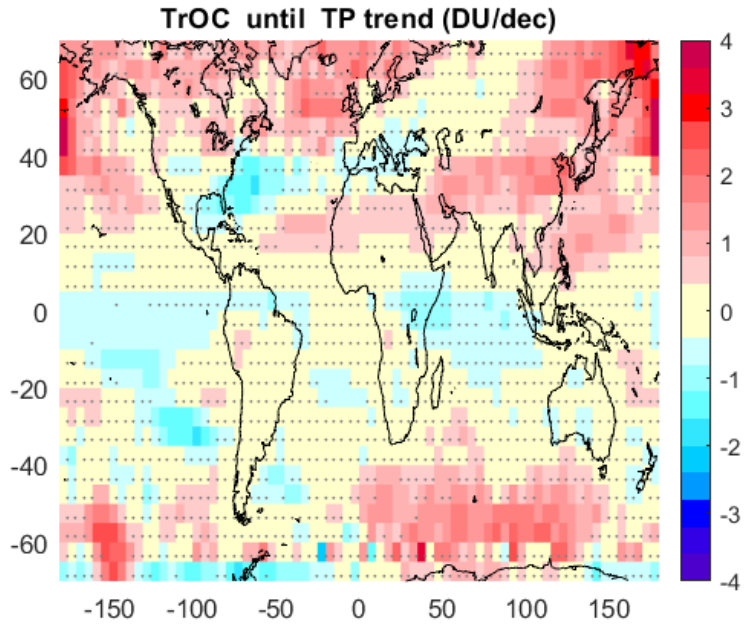
The role of tropospheric ozone on total column ozone trends



total



stratospheric



tropospheric

- Data
  - Total ozone column from OMI
  - Stratospheric ozone column from LIMB-HIRES
- Multiple linear regression on deseasonalized anomalies, years 2004-2021:linear term, QBO, ENSO, solar

- At mid-latitudes, tropospheric ozone trend contribute ~10-20% to total ozone trends
- In the tropics, tropospheric ozone column contributes significantly to total column trends

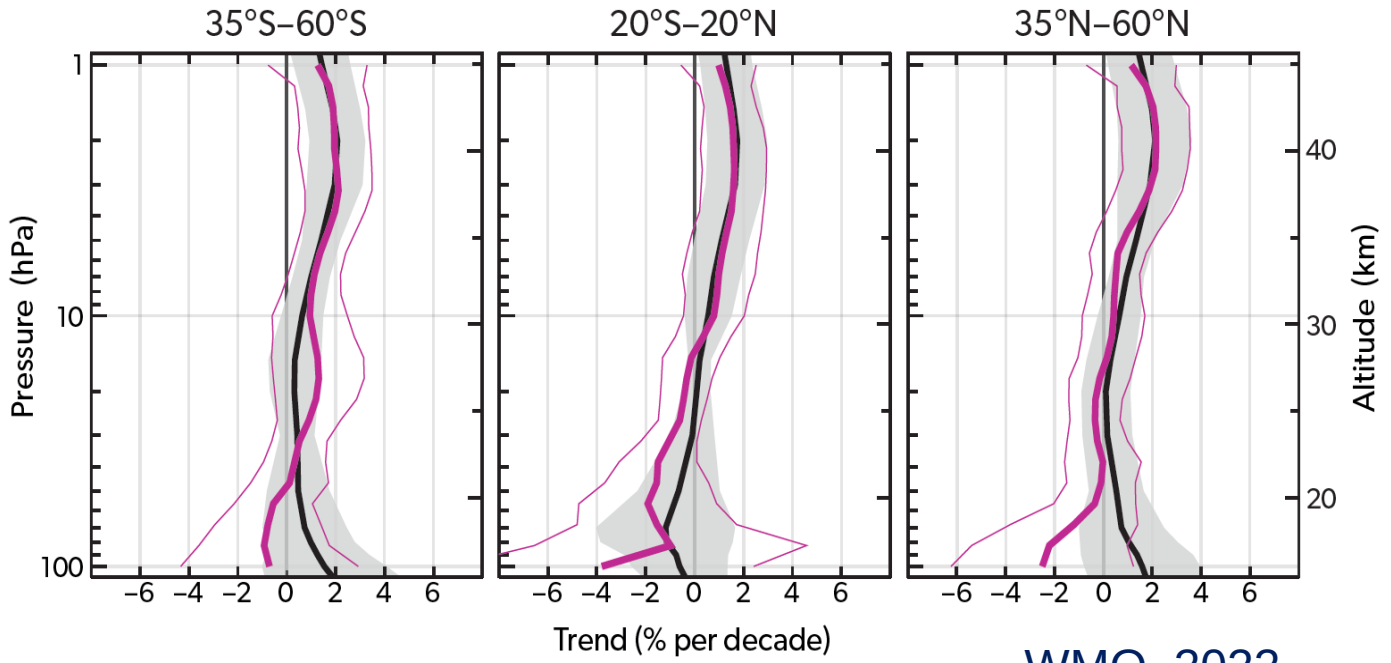
Data availability

- SAGE-CCI-OMPS+ , MEGRIDOP
  - available at CCI, C3S, LOTUS ftp
- High-resolution dataset of ozone profiles (LIMB-HIRES)
  - will be available soon
- Level 2 HARMonized Dataset of Ozone profiles (HARMOZ_ALT and HARMOZ_PRS) for nearly all limb and occultation instruments
  - Available at CCI ftp for ESA and TPM instruments
  - For NASA sensors – on request
- Level 3 monthly zonal mean data from indivudual instruments are available in CCI and C3S data collections

Ozone trends as seen by Ozone_cci merged datasets: short summary and outlook

- All datasets:
  - ozone is recovering in the upper stratosphere
  - The ozone trends in the middle stratosphere are mostly positive, while they are negative in the UTLS
- Specific attention is needed
  - Trends in the UTLS
  - Trends in polar regions

Observed and Simulated Ozone trends 2000 to 2020



WMO, 2022

To address these issues and to monitor ozone recovery, satellite measurements in limb-viewing geometry are important