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Integration of TROPOMI/S-5P total ozone observations in the GTO-ECV data record: Updated perspective on global and regional trends 1995-2021

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Outline

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– GOME-type Total Ozone Essential Climate Variable

– Long-term evolution of total ozone

– Total ozone trends
  – Regional patterns
  – Seasonal variation
  – Comparison with ground-based data

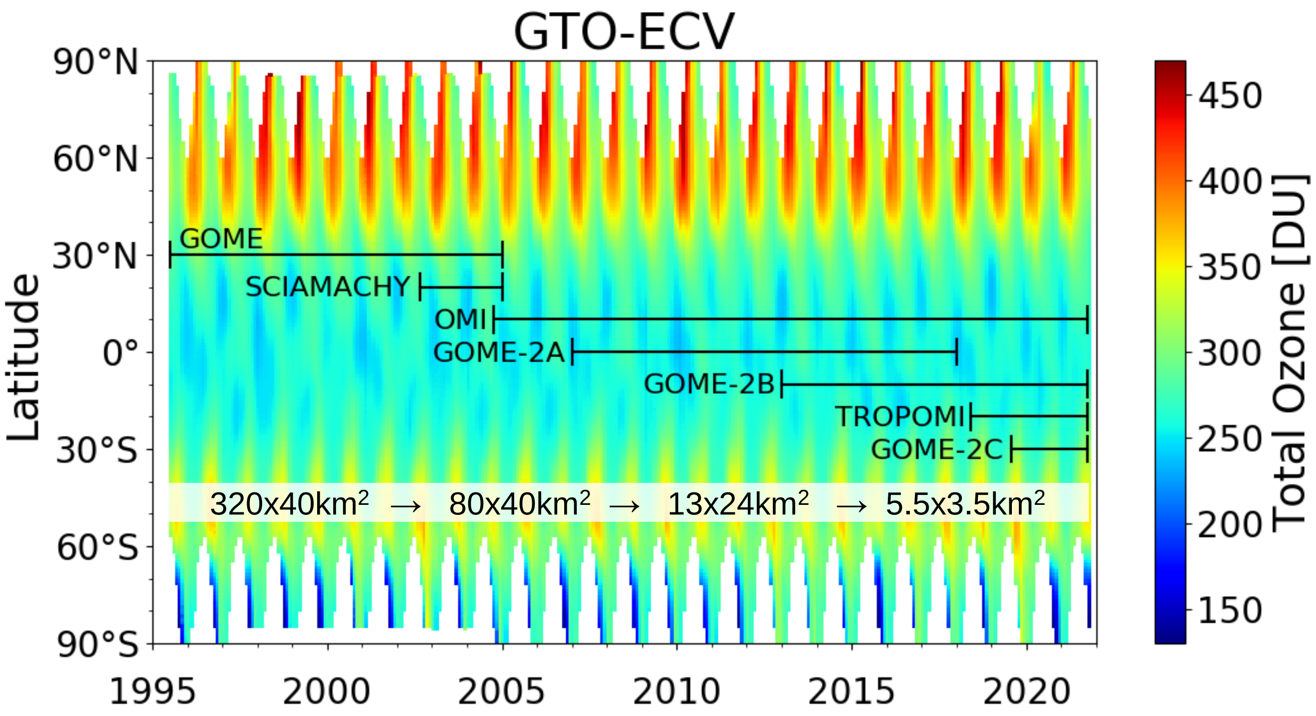
– Summary & Outlook

GTO-ECV

– 7 GOME-type nadir-viewing satellite sensors combined: July 1995 – April2022

– Version 1 generated at DLR in 2009 → Version 2+3 generated as part of ESA-CCI/CCI+ → Regularly extended as part of EU C3S → Free download via Climate Data Store

– Ozone retrieval: GODFIT V4 (Lerot et al., 2014) → Very high inter-sensor consistency



– Merging approach: OMI as a reference (overlap with all other sensors + quite stable)

– 1°x1° monthly means + error information

– Loyola et al. (2009), Loyola and Coldewey-Egbers (2012), Coldewey-Egbers et al. (2014, 2015, 2020, 2022), Garane et al. (2018)

GTO-ECV latest additions

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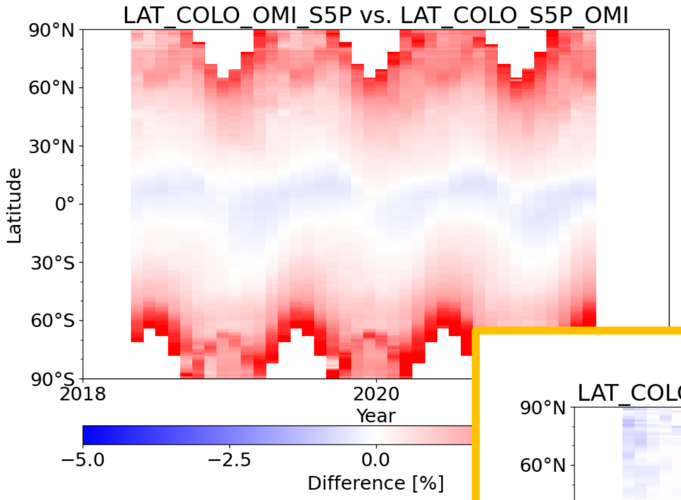
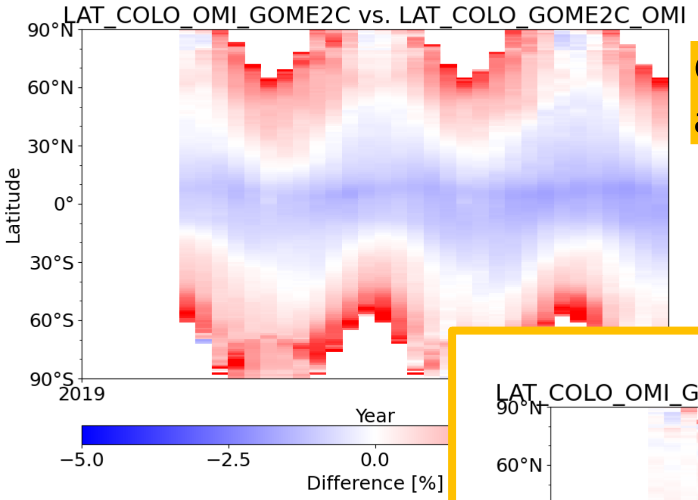
- TROPOMI/Sentinel-5P (since 05/2018) and GOME-2/MetOp-C (since 07/ 2019)
- Adjustments depend on latitude and month

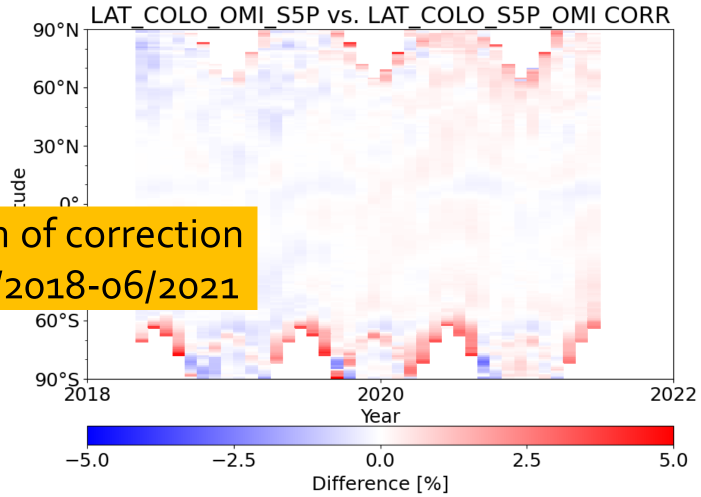


TROPOMI/S-5P before adjustment w.r.t. OMI

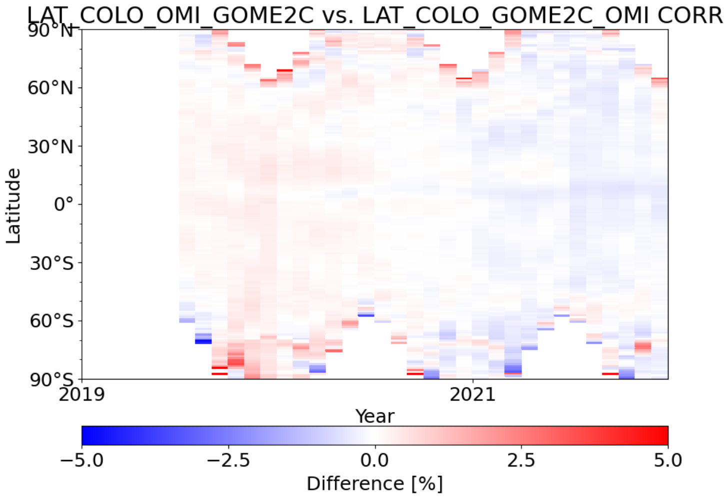


GOME-2C before adjustment w.r.t. OMI

Note: determination of correction factors based on 05/2018-06/2021



TROPOMI after adjustment w.r.t. OMI



GOME-2C after adjustment w.r.t. OMI

Long-term evolution of ozone

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Motivation

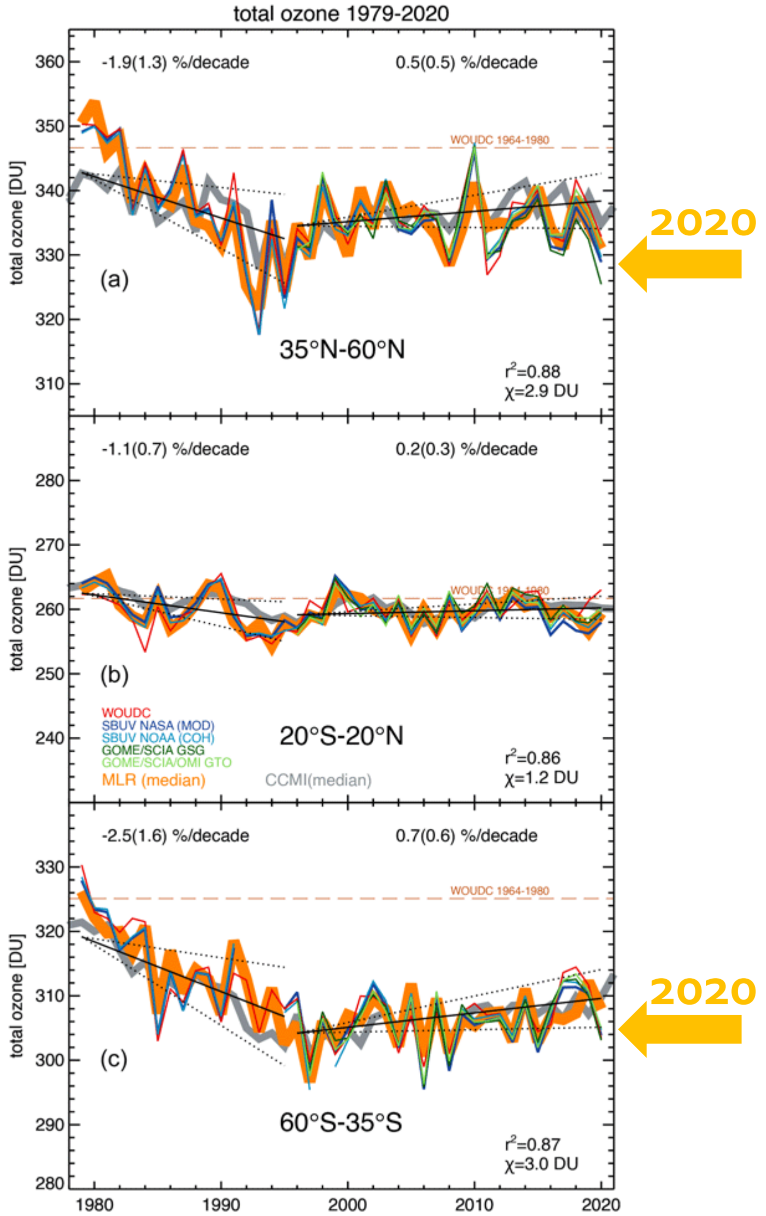
– Confirm the expected increase in total ozone as a consequence of decreasing amounts of ODSs on a global scale

– Weber et al. (2022), BAMS "State of the Climate"

  – Since the end of the '90s, total ozone remained stable - still below 1964-1980 mean – and with substantial year-to-year variability

  – In 2020/2021 total ozone in middle and high latitudes were below the average of the past two decades

– Derive regional trend patterns

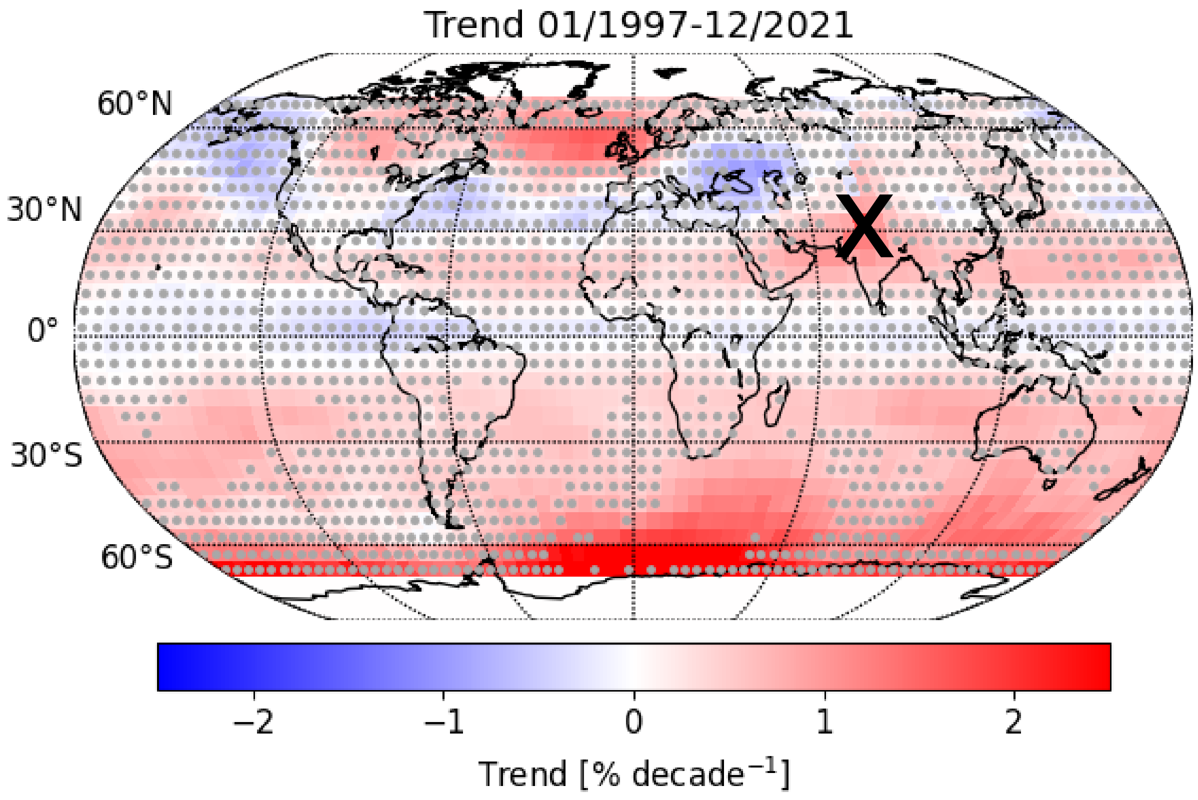


Weber et al., ACP, 2022

Annual mean trend

Trend model

- Multiple linear regression (MLR, Coldewey-Egbers et al., 2014 & 2022)
- $O_3(m) = A + B \cdot m + C \cdot SF(m) + D \cdot QBO30(m) + E \cdot QBO50(m) + F \cdot MEI(m) + \underline{G \cdot (A)AO(m)} + X$

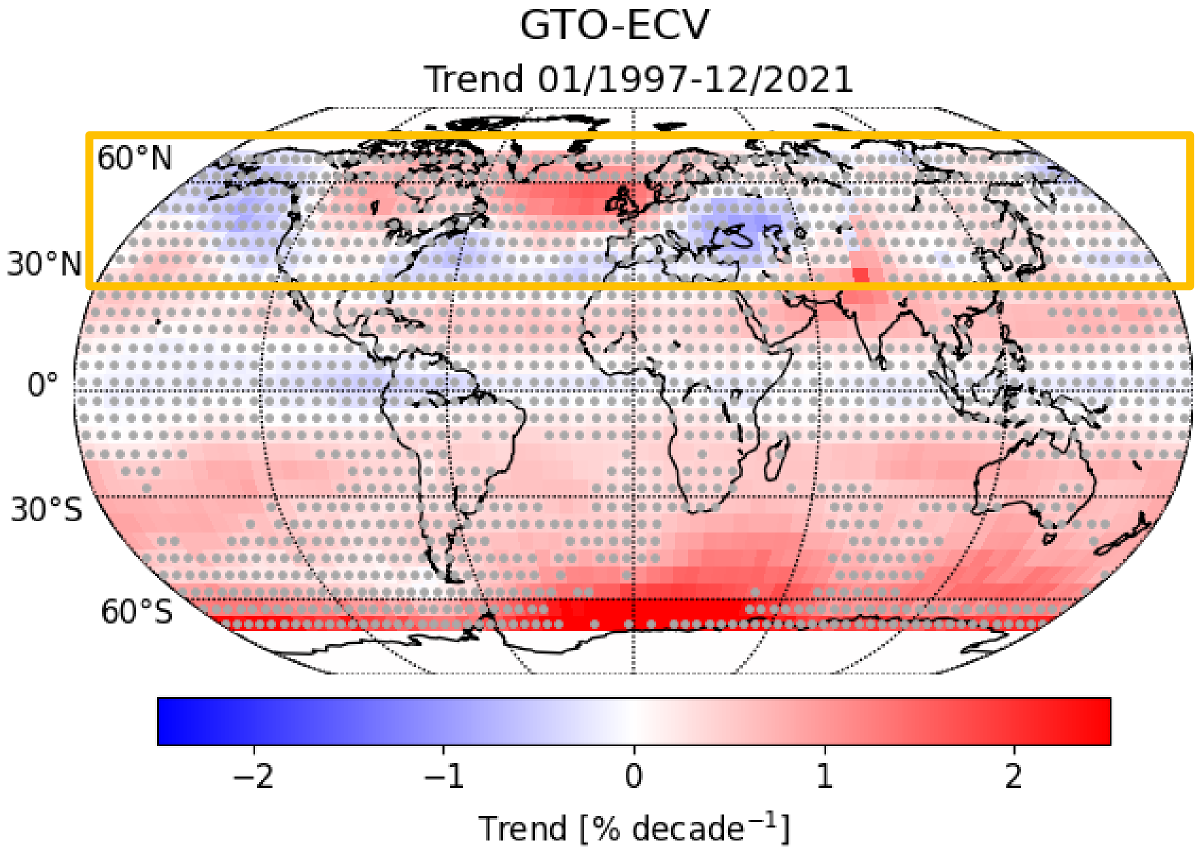


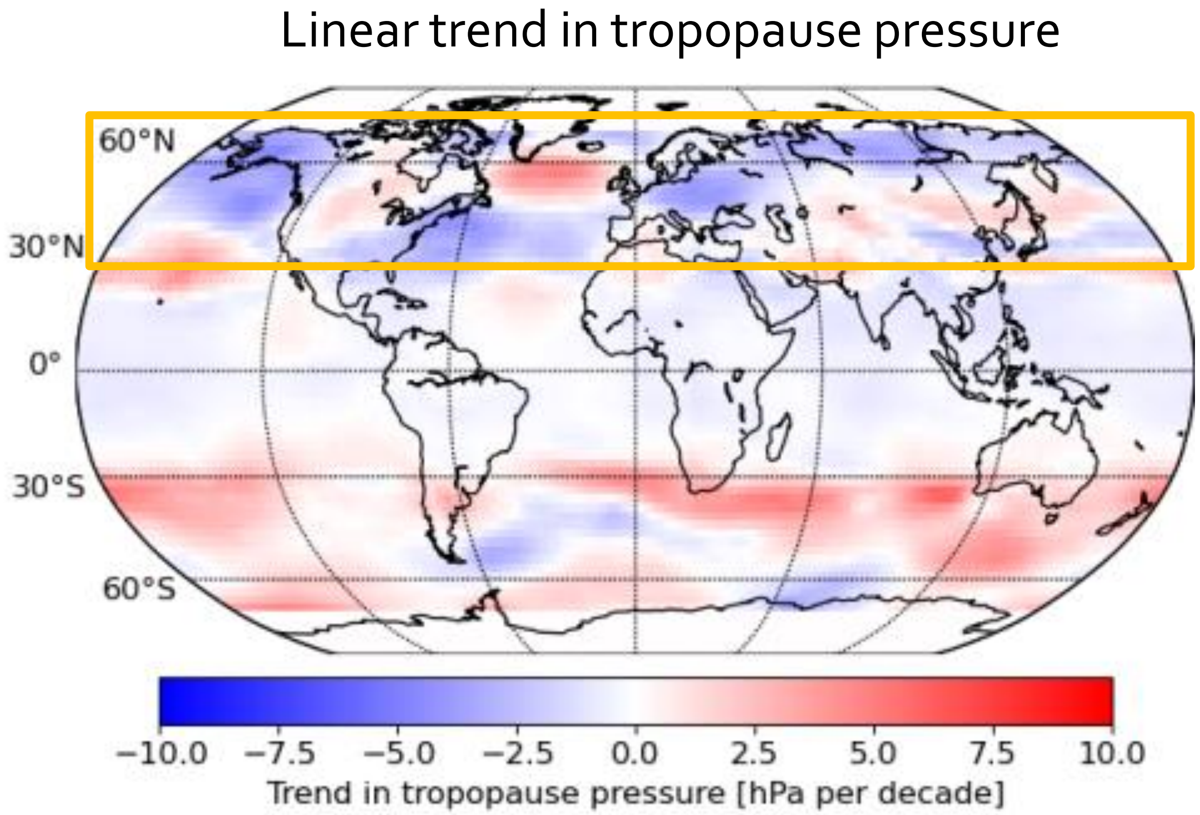
Main findings

- Including 2021 → no significant change in overall pattern or significance of trends
- SH: significant positive trends
  - **0.6±0.5%/dec** (subtropics)
  - **2.8±2.6%/dec** (60°-70°S)
- NH: longitudinal structures → positive trends over the North Atlantic & barely significant negative trends over eastern Europe

Correlation with tropopause

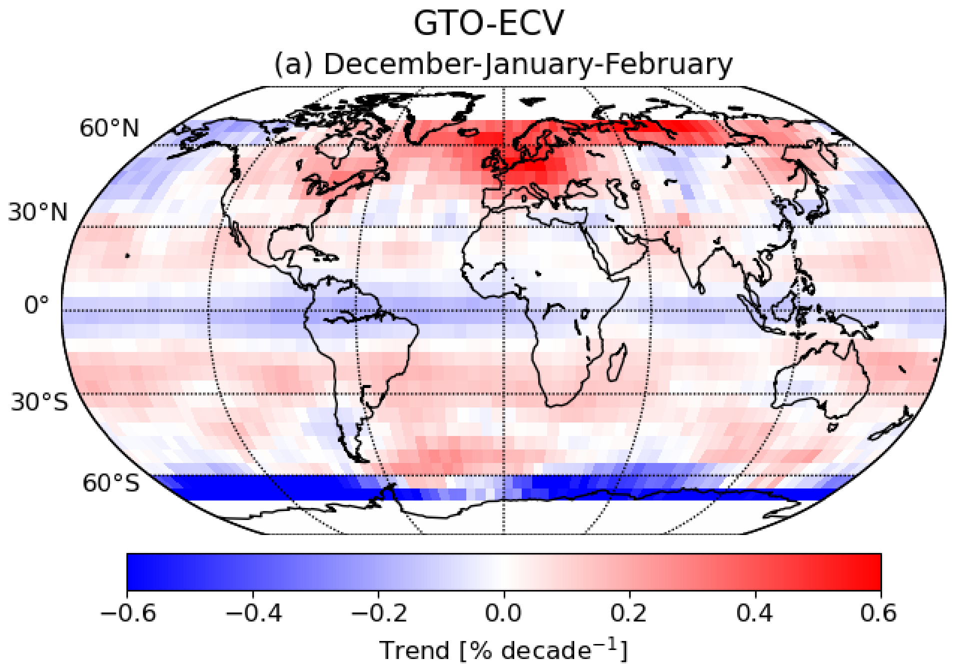
- Simple linear trend in tropopause pressure from NCEP/NCAR reanalysis
- Same spatial pattern as trend in ozone

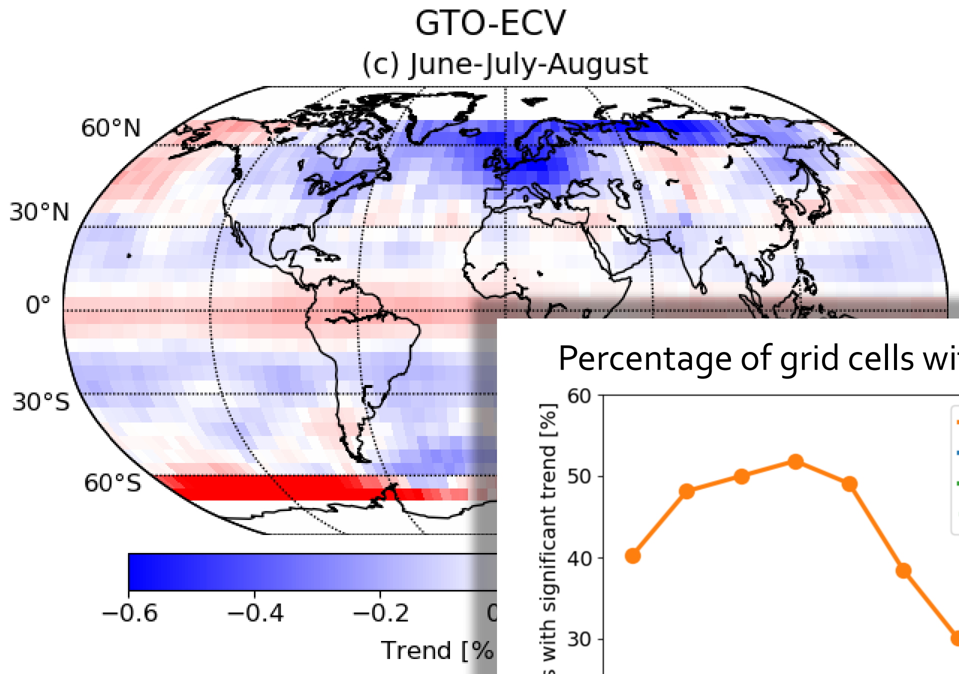


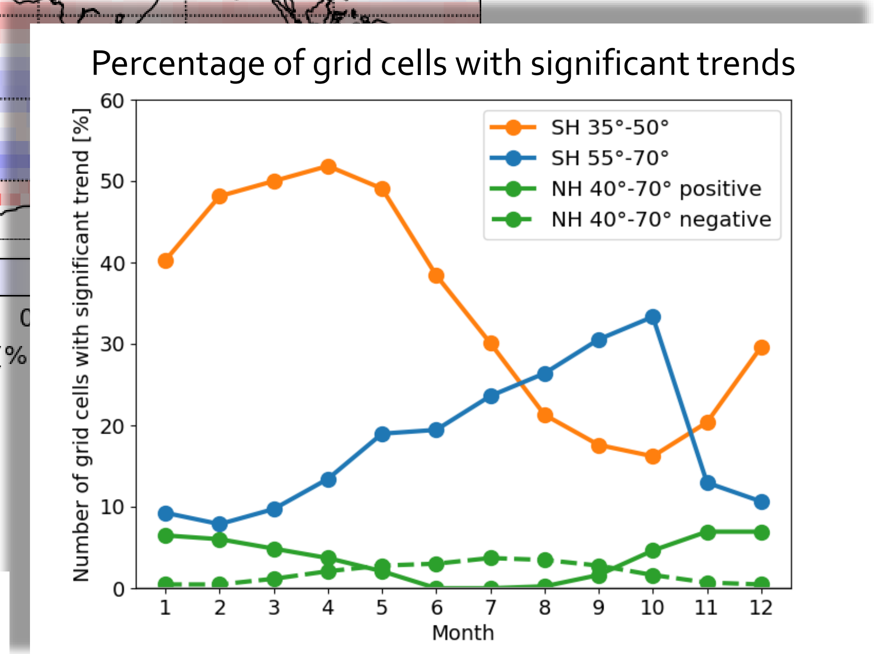


Seasonal variation

- Expand MLR including seasonal terms for trend
- Deviation from annual mean trend for Dec-Feb (left) and Jun-Aug (right)

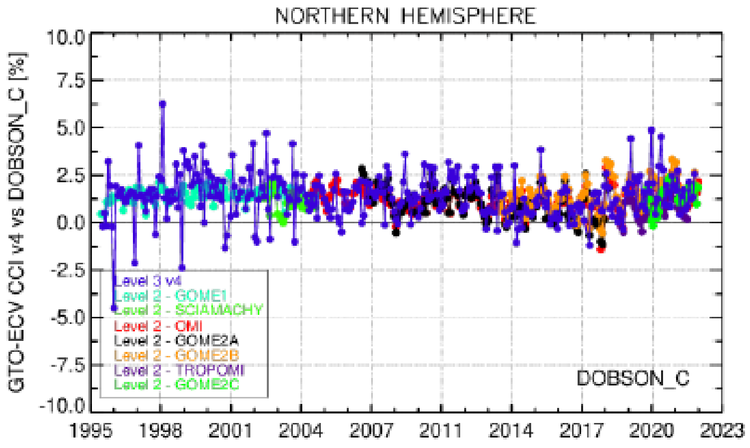


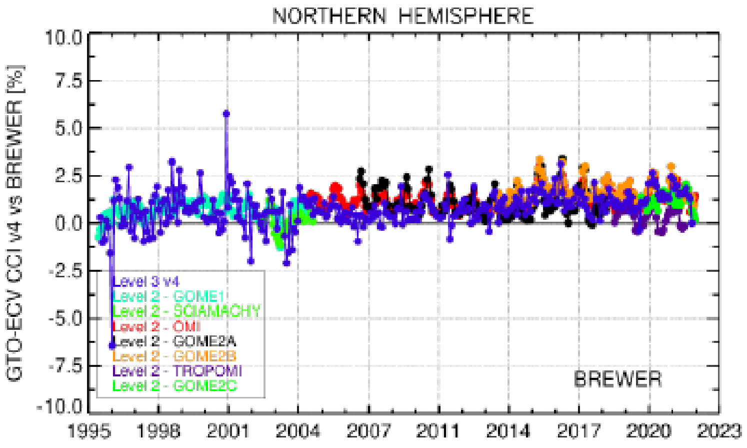




- Maximum trend in local winters maybe related to BDC

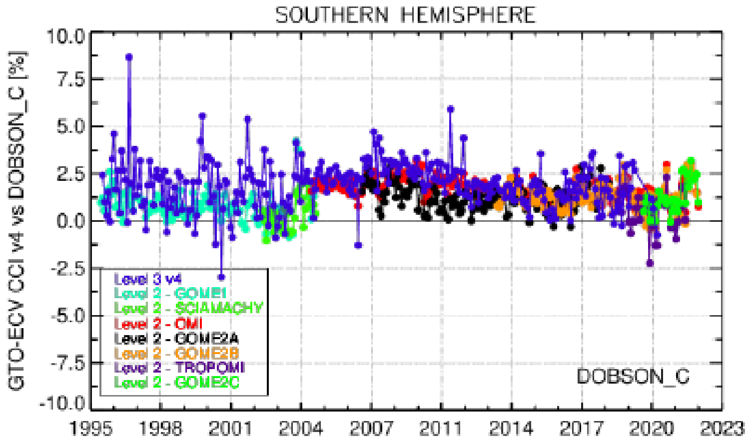
Comparison with GB data





Validation approach

- Comparison with Dobson (SH and NH) and Brewer (NH only) instruments
- At least 10 measurements/month



Courtesy of K. Garane, AUTH

Main findings

- Very good overall agreement → mean bias 1.4±1.2%
- ~1% peak-to-peak amplitude
- Consistency with Level-2 data → outliers due to sampling
- Drift < 1% per decade → within GCOS requirements
- Validation results in Garane et al. (2018), ESA Ozone_cci+ PVIR (2022), C3S Ozone PQAR (2021)

Trends derived from GB data (i)

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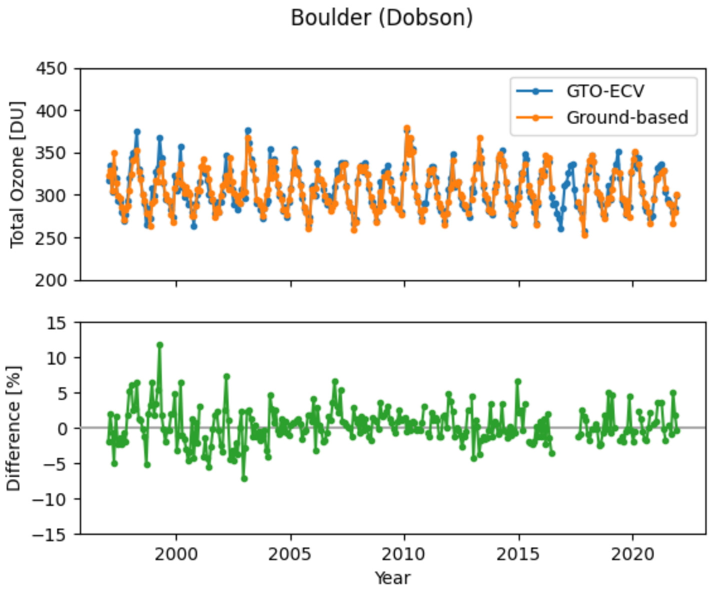
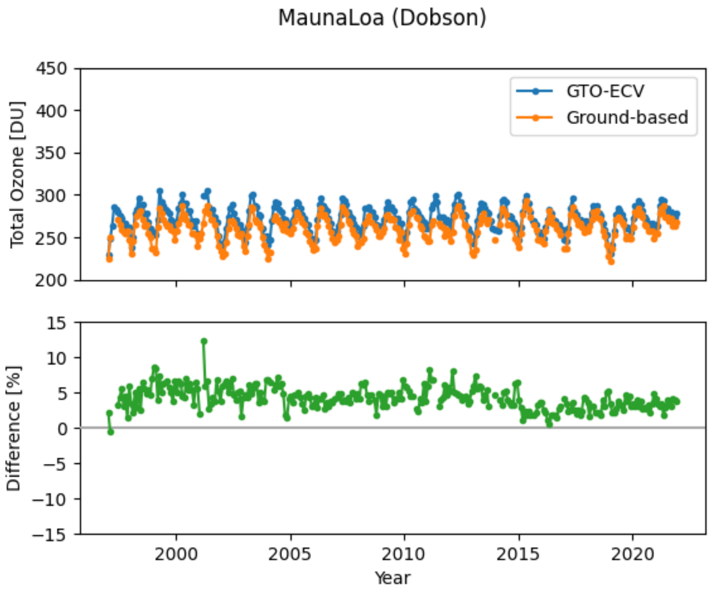
Selection of ground-based stations

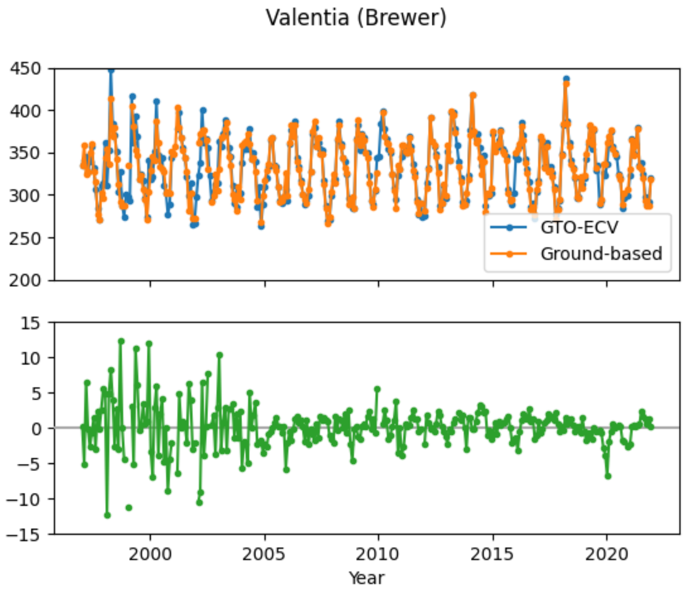
- At least 80% of months (240/300) must be available → 5 Dobson + 8 Brewer stations
- Only <u>one</u> in region with significant positive trend → Valentia Island / Ireland
- Trends based on 1°x1° GTO-ECV data



Boulder
Difference: 0.3±2.5%
Drift: 0.0%/dec



MaunaLoa
Difference: 4.3±1.6%
Drift: -0.9%/dec



Valentia
Difference: 0.1±3.1%
Drift: -0.1%/dec

Trends derived from GB data (ii)

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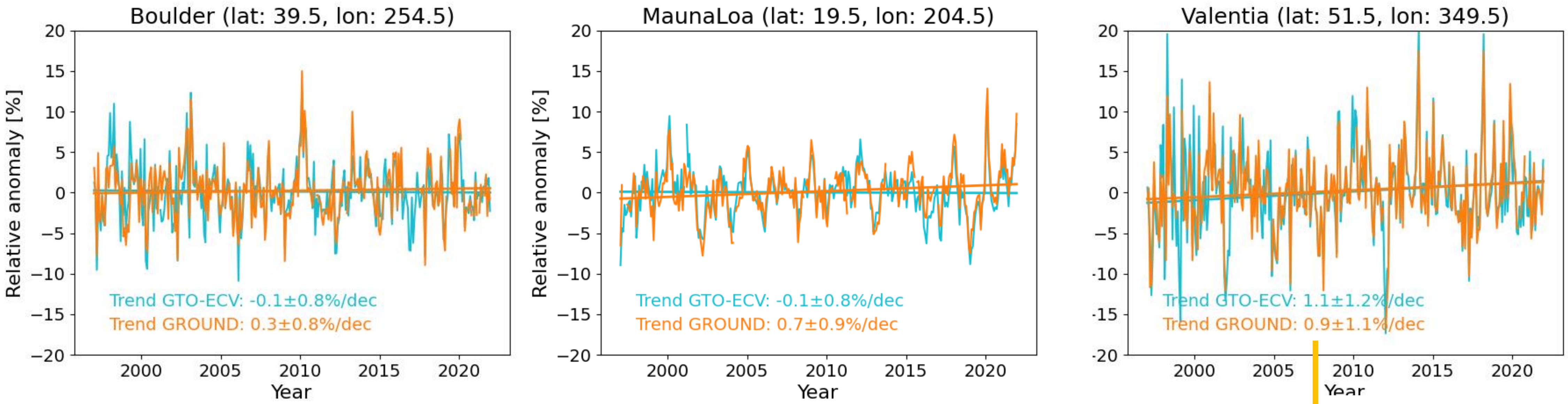
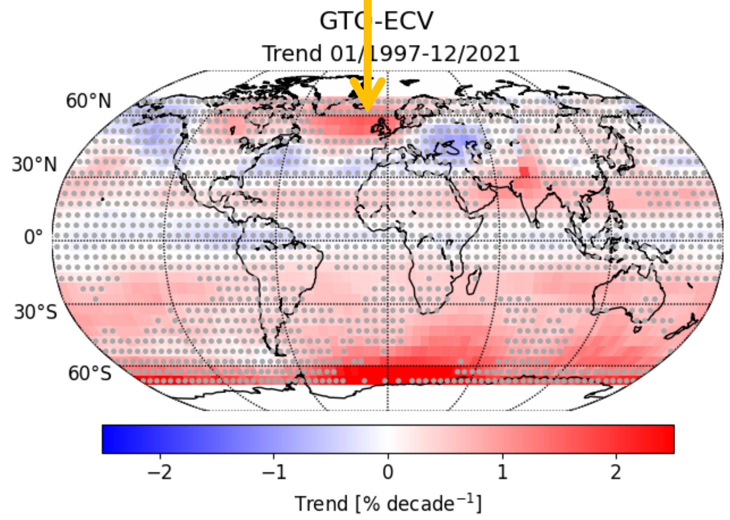


- Analysis preliminary and quite limited so far
- Maybe requirements for station selection too strict
- 2σ errors of trend fit agree well for all stations
- Good agreement for Valentia



Summary

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- TROPOMI/S-5P and GOME-2C data added in GTO-ECV
- Updated trend analysis until Dec 2021
- Significant positive trends only in SH + impact of dynamics in NH
- Very small seasonal variations
- ACP, May 2022

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Atmospheric Chemistry and Physics
Open Access
EGU

Global, regional and seasonal analysis of total ozone trends derived from the 1995–2020 GTO-ECV climate data record

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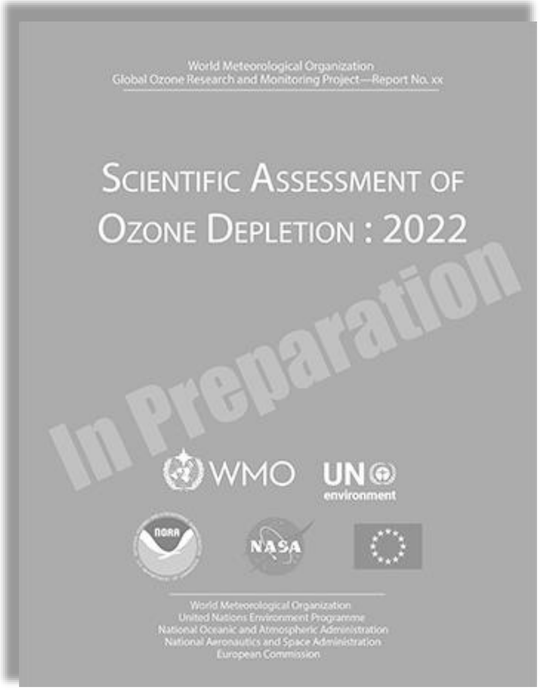

New WMO assessment will be published end of 2022

Outlook

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GOME-type Total Ozone Essential Climate Variable

– New reference sensor needed → OMI end of life ~2023

GOME-type Ozone Profile Essential Climate Variable

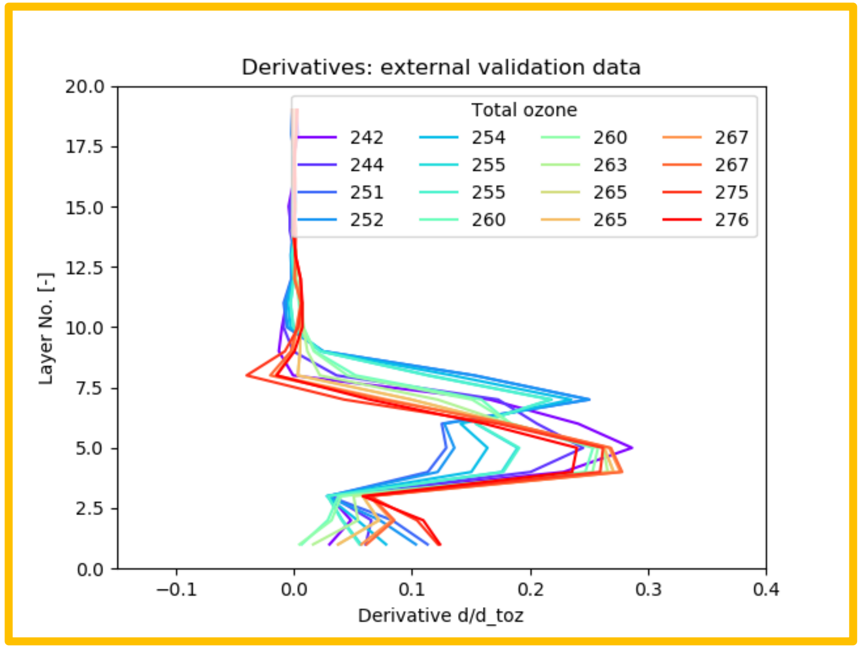
– In the framework of ESA-CCI+ ozone project

– Based on same satellite sensors (except for TROPOMI and GOME-2C)

– Ozone profiles retrieved with RAL scheme (Miles et al., 2015)

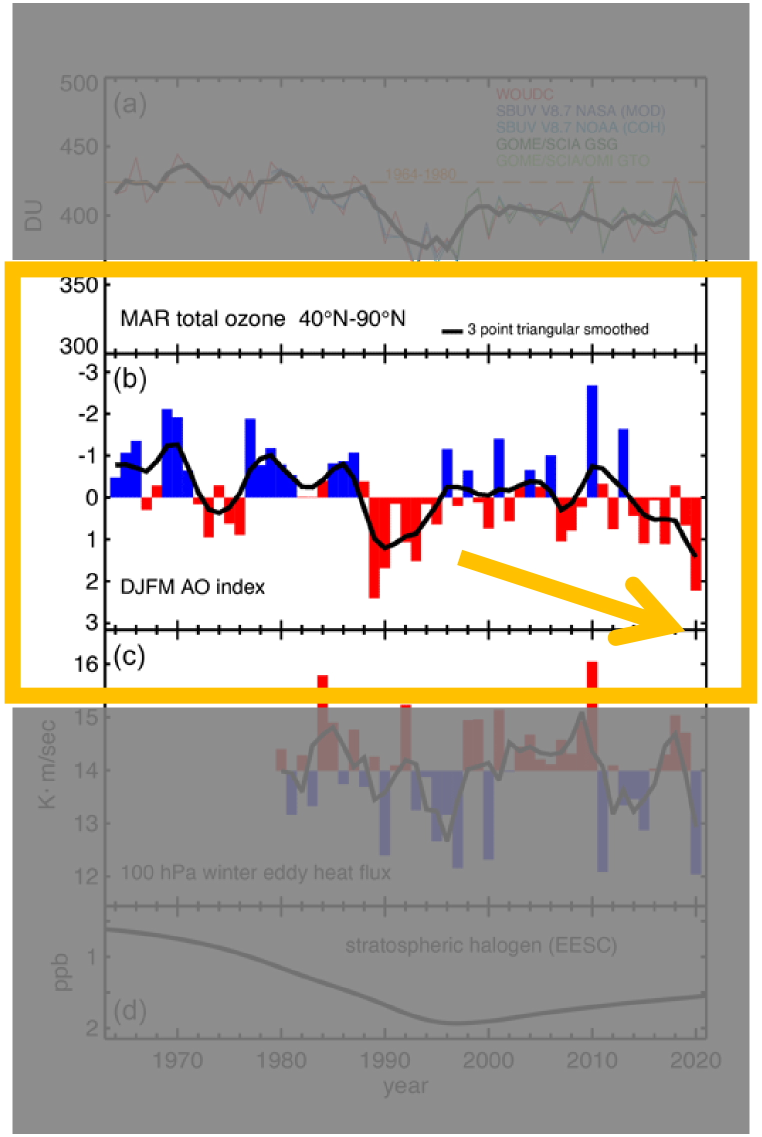
– Merging approach based on de-seasonalized anomalies

– Harmonization w.r.t. GTO-ECV total columns
→ altitude dependent adjustment



Extra slides

Extra slides



Weber et al., ACP, 2022
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