Comparison of GTO-ECV and adjusted MERRA-2 total ozone columns

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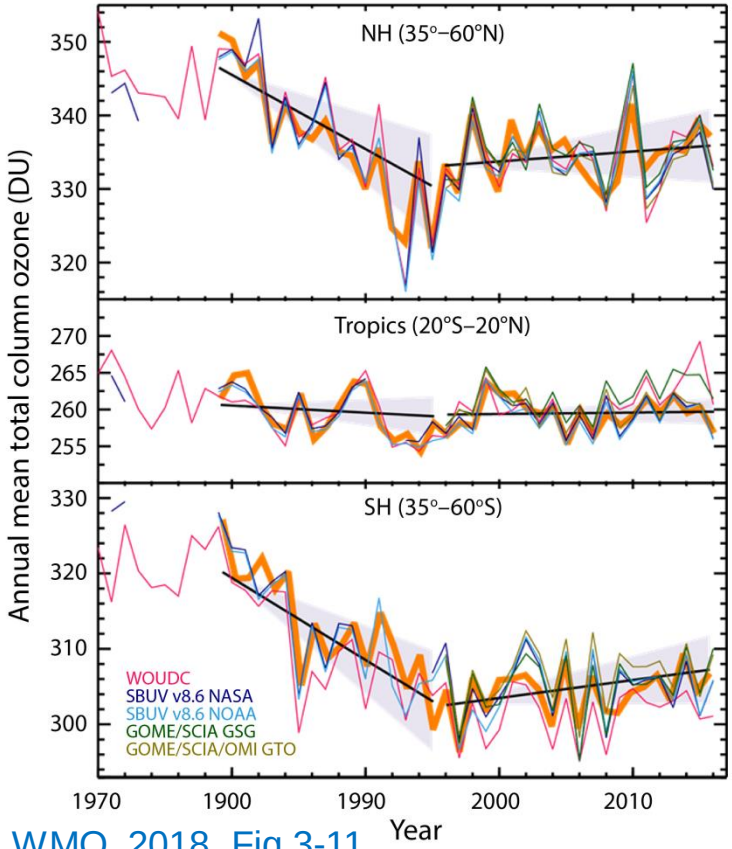
DLR

Outline

- Motivation
- Data records GTO-ECV and adjusted MERRA-2
- Intercomparison of total ozone columns
- Extension of GTO-ECV using TROPOMI/S5P
- Outlook

Motivation

- Decline in amount of ODSs as a consequence of the 1987 Montreal Protocol
- Recovery expected but not yet visible on a global scale due to strong dynamically-induced inter-annual variability
- First signs of recovery in SH, the upper stratosphere and in Antarctic (September)
- 2019 Antarctic ozone hole was smallest on record
- March 2020: record low ozone values in Arctic
- ➢ Robust analysis requires accurate, consistent, global, long-term data records



WMO, 2018, Fig.3-11

Data records

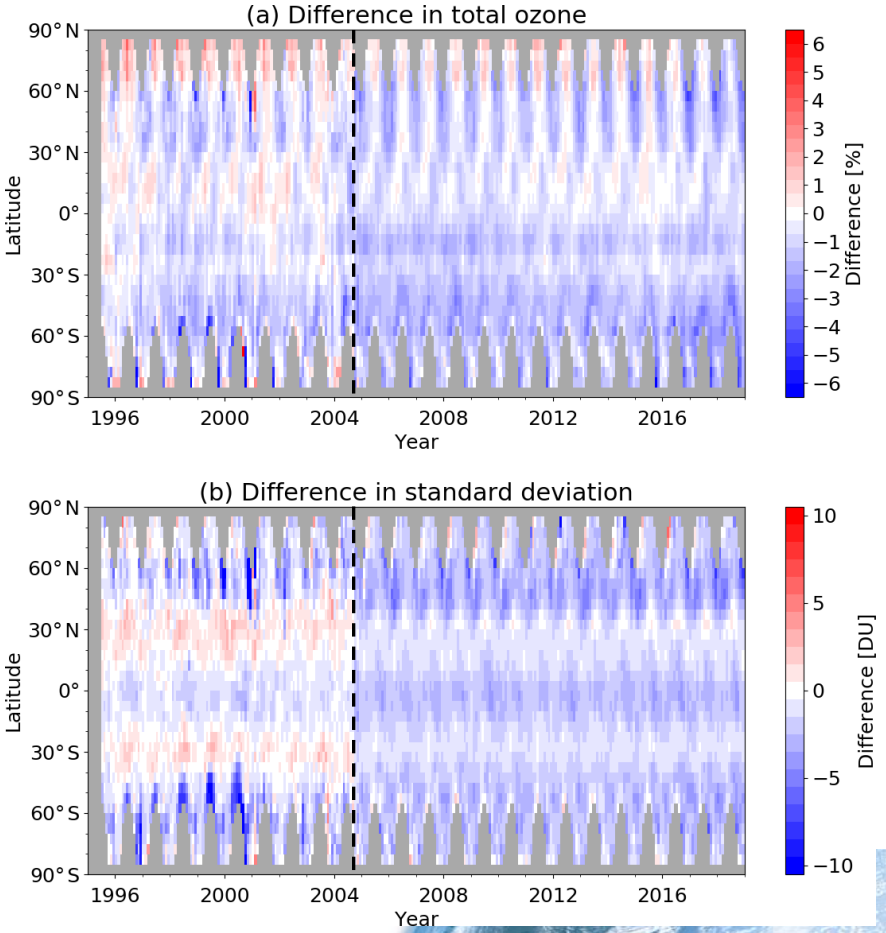
GOME-type Total Ozone Essential Climate Variable (GTO-ECV)

- 5 nadir-viewing UV-VIS satellite sensors: **GOME, SCIAMACHY, OMI (reference), GOME-2A/B, (+TROPOMI)**
- 1995 – 2019, 1° x1° monthly means
- **Ground-based validation:** 0.5-1.5% peak-to-peak amplitude temporal stability meets GCOS requirements (1%/dec)
- **Regular updates:** C3S ozone project
- **References**: Coldewey-Egbers et al., AMT, 2015; Lerot et al., JGR, 2014, Garane et al., AMT, 2018.

Adjusted Modern Era Retrospective Analysis for Research and Applications

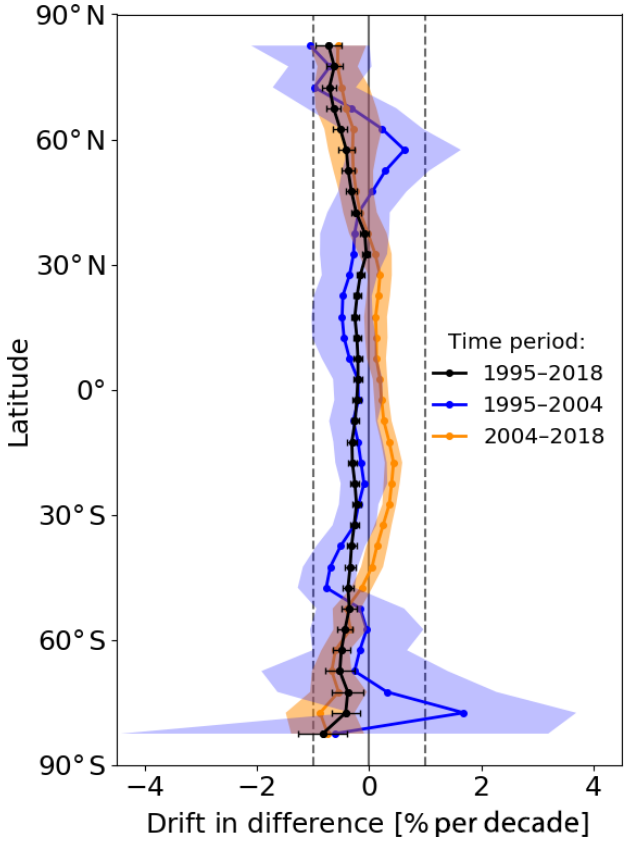
- Provided by G. Labow and S. Frith (NASA)
- 1980 – 2018, high spatial and temporal resolution
- Assimilation of ozone information from SBUV/2, MLS, IASI, SUOMI-NPP, OMI
- Discontinuities detected
- Normalize MERRA-2 w.r.t. NASA-MOD total ozone data record based on 5° zonal monthly means
- **References:** Bosilovich et al., 2015; Frith et al., JGR, 2014; Wargan et al., JC, 2017.

Comparison of 5° zonal monthly means



- **Difference in total ozone:**
  (adj. MERRA-2 – GTO-ECV) / GTO-ECV
- **October 2004:**
  Introduction of OMI in both data records
- **Total Ozone:**
  Difference (<10/2004): -0.5 ± 1.1%
  Difference (>10/2004): -1.0 ± 1.0%
- **Standard Deviation:**
  Difference (<10/2004): -0.7 ± 2.1DU
  Difference (>10/2004): -1.4 ± 1.3DU

Drift in differences

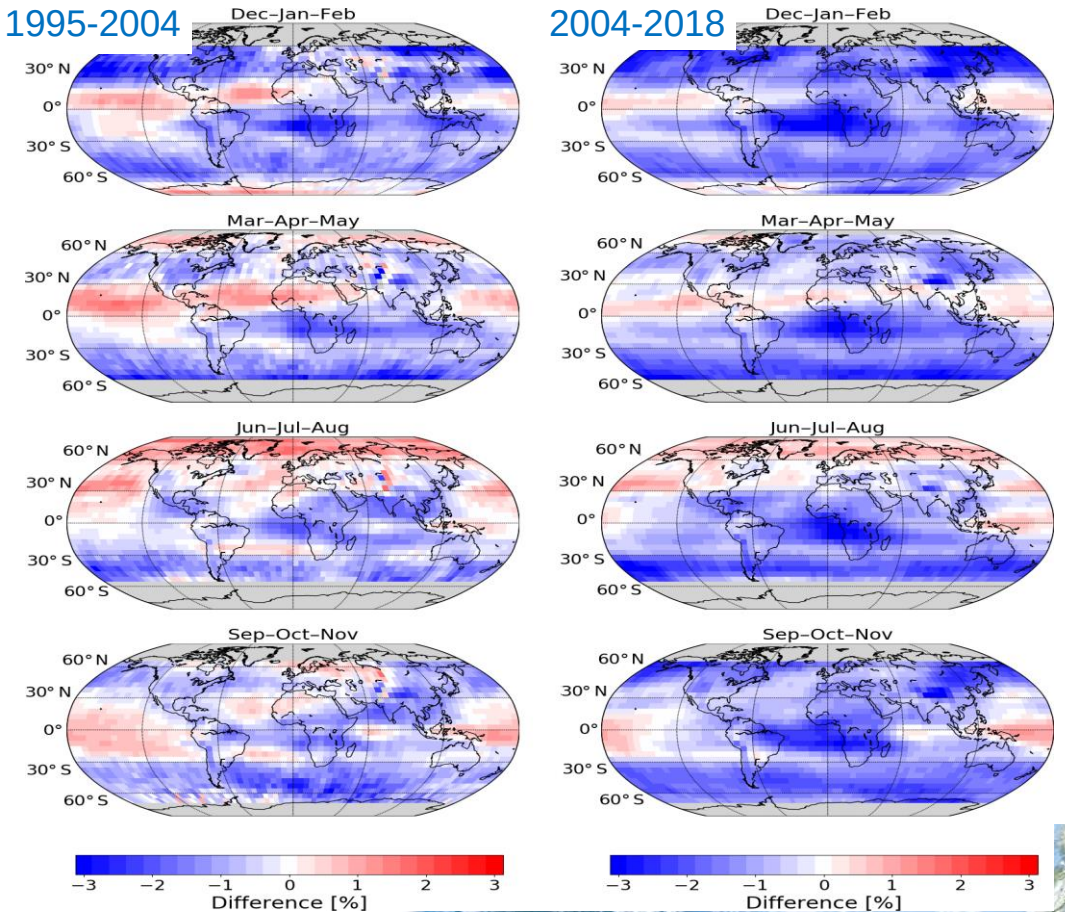


- Investigate impact of „discontinuity“ in October 2004
- Linear fit applied to differences for three time periods:

  1995-2018 (black)
  1995-2004 (blue)
  2004-2018 (orange)

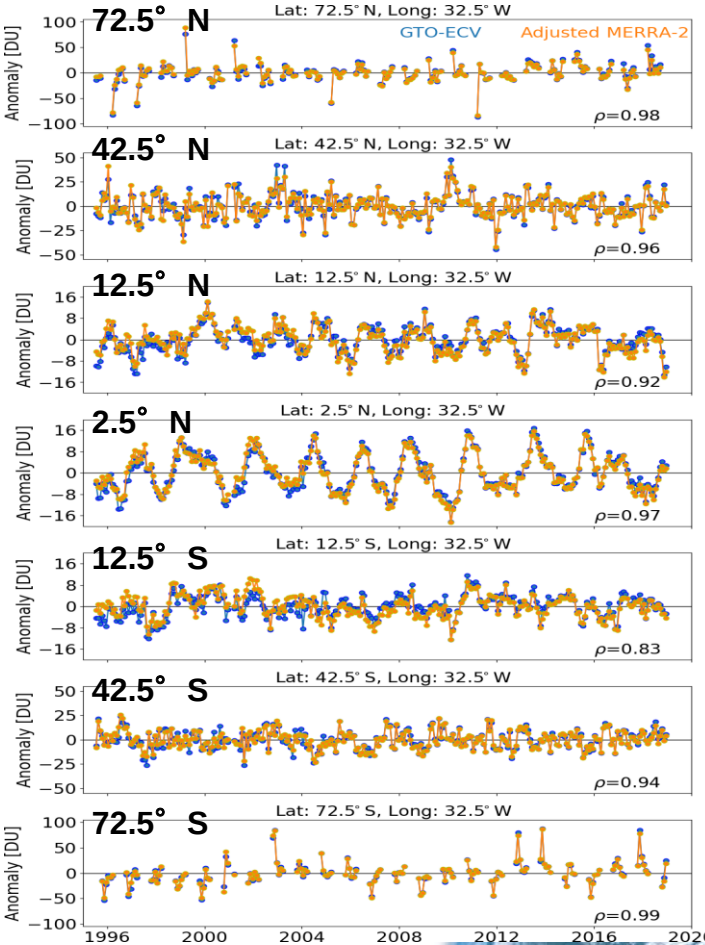
- Drift well below 1% per decade (dashed vertical lines)

Spatial patterns in differences

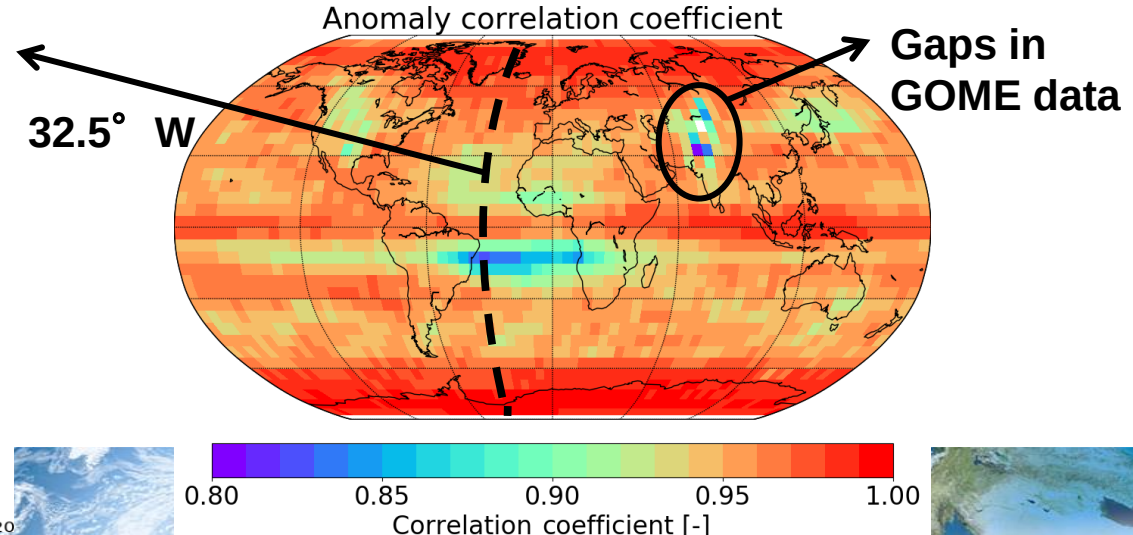


- Seasonal means of differences (5° x5°) for two time periods: 1995-2004 and 2004-2018
- Spatial patterns quite similar for both time periods
- Tropics: differences indicate longitudinal structure; maximum negative difference in southern tropical Atlantic

Ozone Anomalies

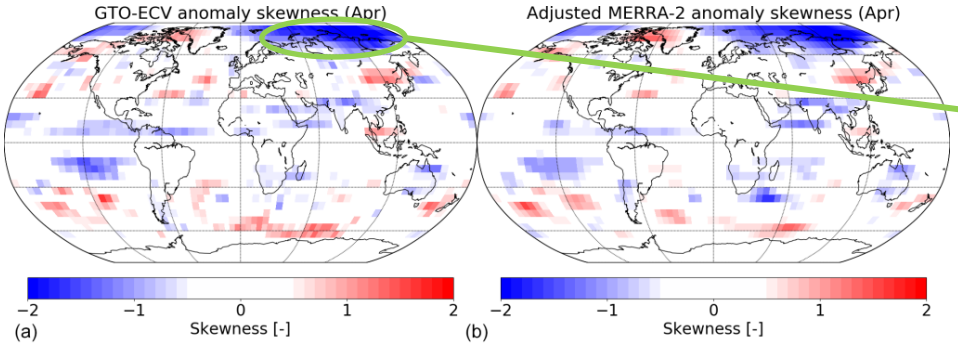


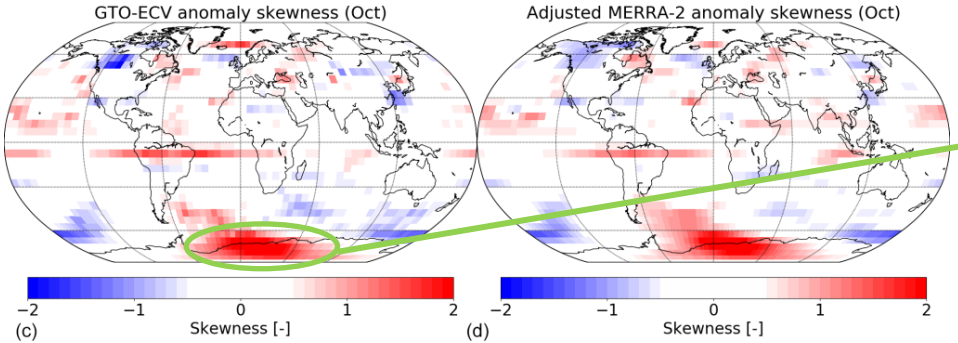
- Compute anomalies (w.r.t. 1995-2018 period) for each data record and each grid box
- Compute correlation coefficient ρ for each grid box
- 97.5% of grid boxes: ρ>0.90
- Median: ρ=0.96, minimum: ρ=0.76

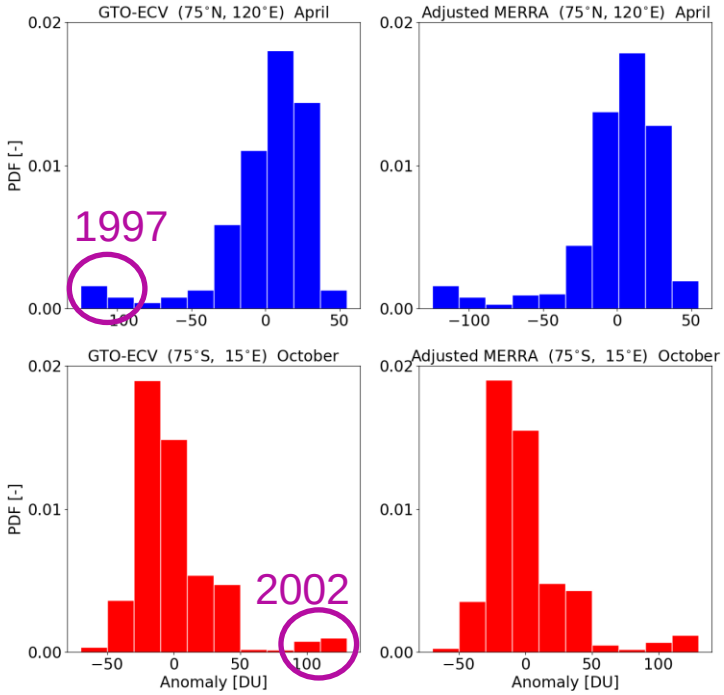


Moments of anomalies (skewness)

Skewness < 0

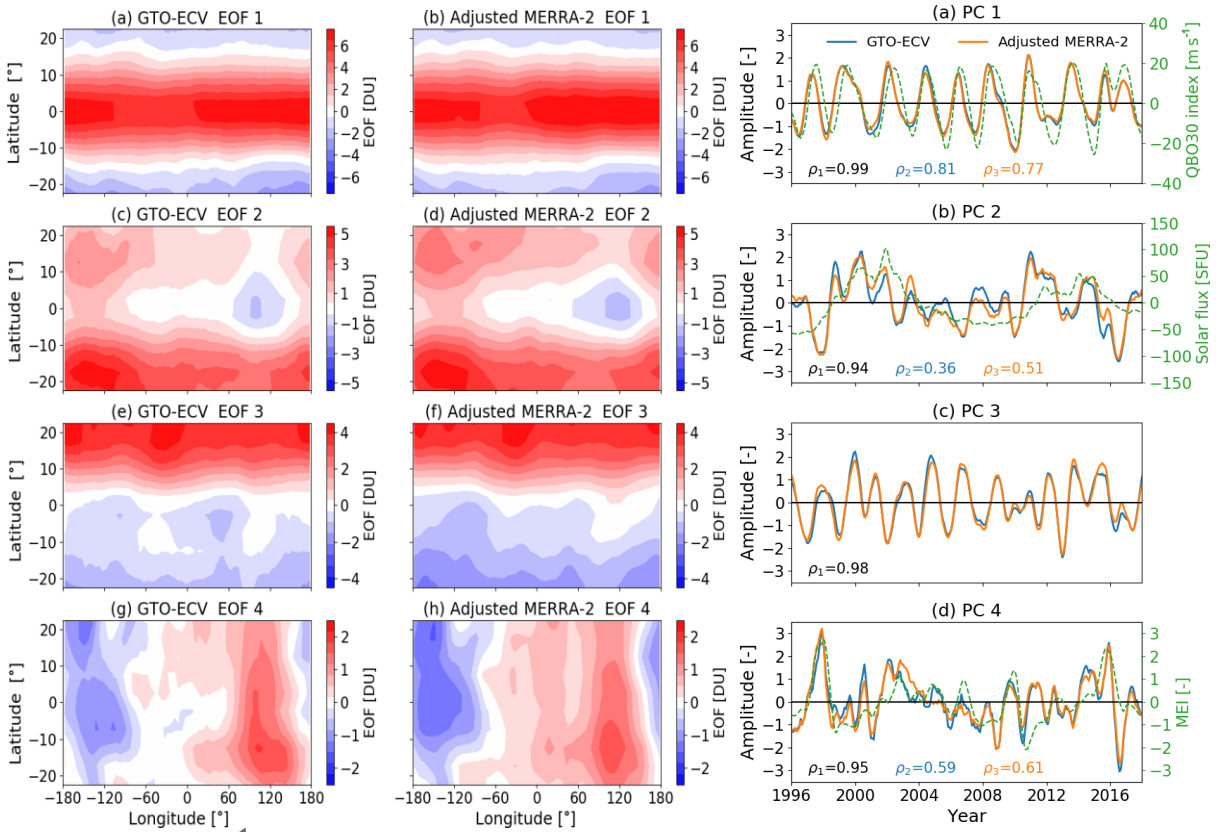






Skewness > 0

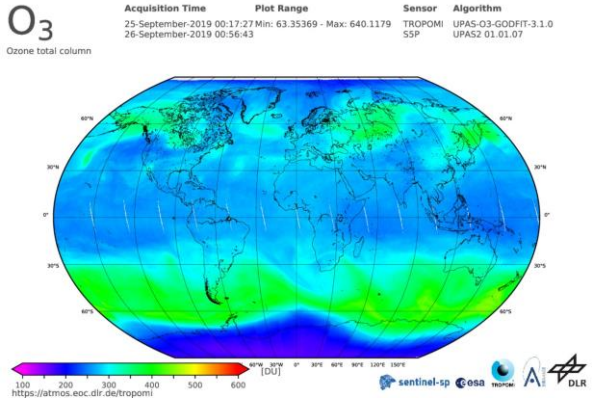
EOF analysis in the tropics (25° S-25° N)



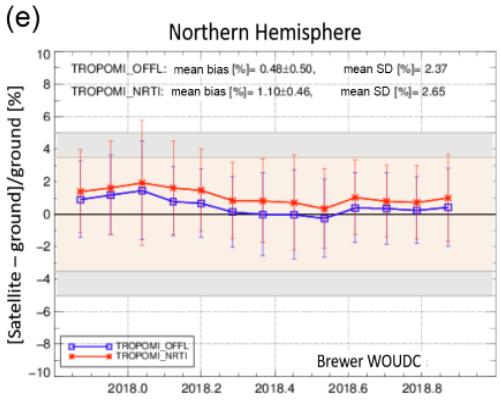
- Spatial patterns, PC time series and Fourier spectra show very good agreement
- PCs can be attributed to different modes of climate variability:
  - **PC 1:** QBO index at 30hPa, f = 28 months
  - **PC 2:** solar cycle, f ≈ 138 months
  - **PC 3:** „QBO-annual beat“-frequency (21 months)
  - **PC 4:** ENSO, f > 3.5 years

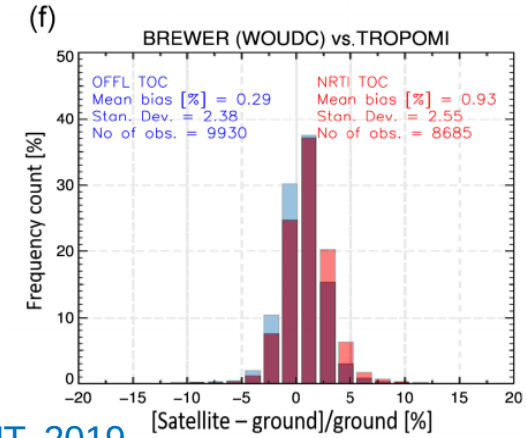
Extend GTO-ECV using TROPOMI/S5P (1)

- Ground-pixel size 3.5x5.5km^2
- Daily global coverage
- Two total ozone products:
  - NRTI (GDP: iterative DOAS)
  - OFFL (GODFIT)



https://atmos.eoc.dlr.de/tropomi

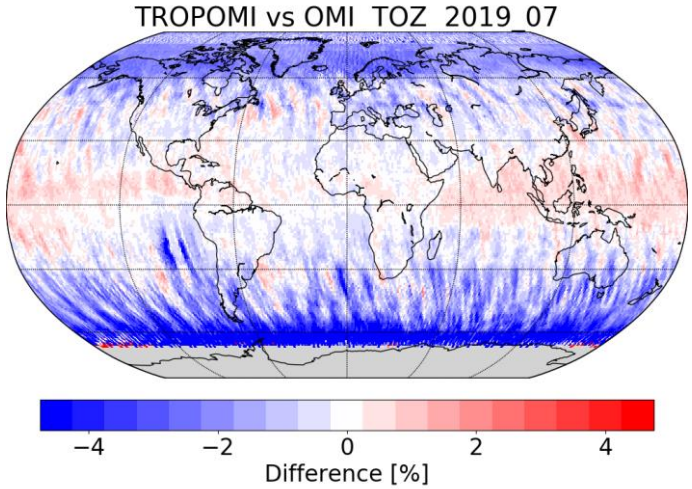


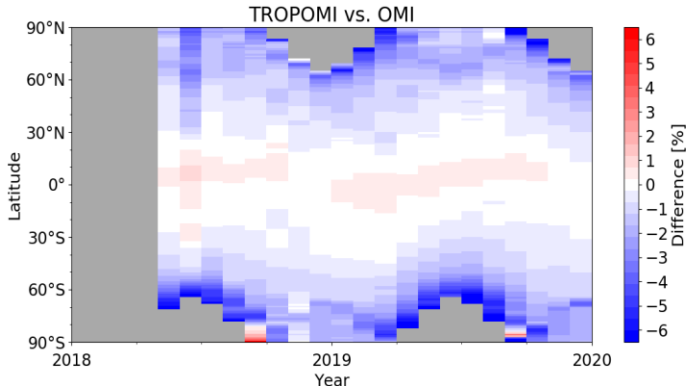


Garane et al., AMT, 2019

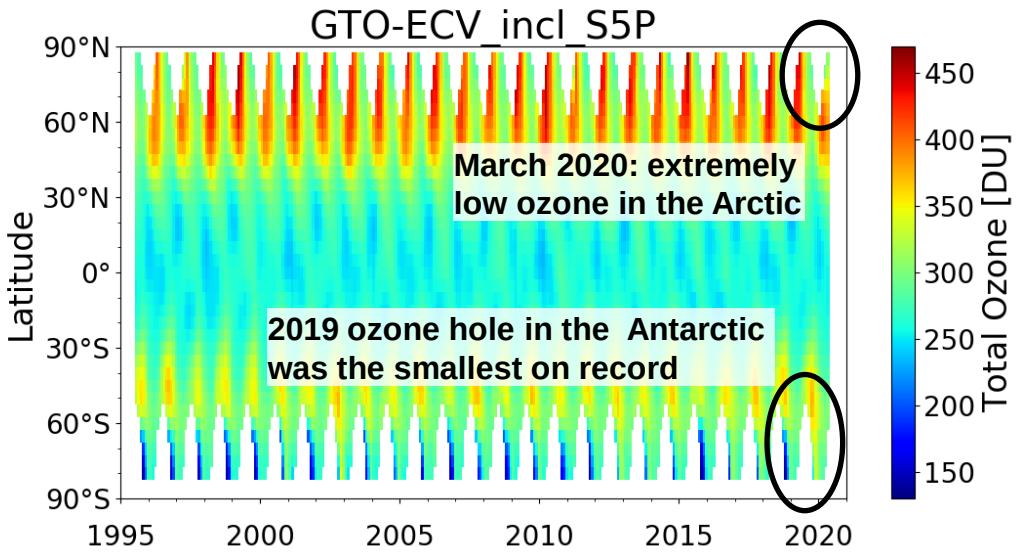
- Ground-based validation mean bias:
  - OFFLN less than ±1%
  - NRTI less than ±1.5%
- Very good agreement with other satellite
- OFFL product will be used in GTO-ECV

Extend GTO-ECV using TROPOMI/S5P (2)





- TROPOMI total ozone columns 05/2018 - 04/2020
- TROPOMI vs. OMI mean difference: -1.0%±1.4%
- Apply correction as a function of latitude and month



Summary and Outlook

- Very good agreement between GTO-ECV and adjusted MERRA-2 ozone columns
- Long-term drift of differences well below 1%/decade
- Excellent agreement of ozone anomalies
- Results published in AMT in April 2020

- Extension of GTO-ECV using TROPOMI/S5P

- Use GTO-ECV for decadal trend studies and for model evaluation

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Comparison of GTO-ECV and adjusted MERRA-2 total ozone columns from the last 2 decades and assessment of interannual variability

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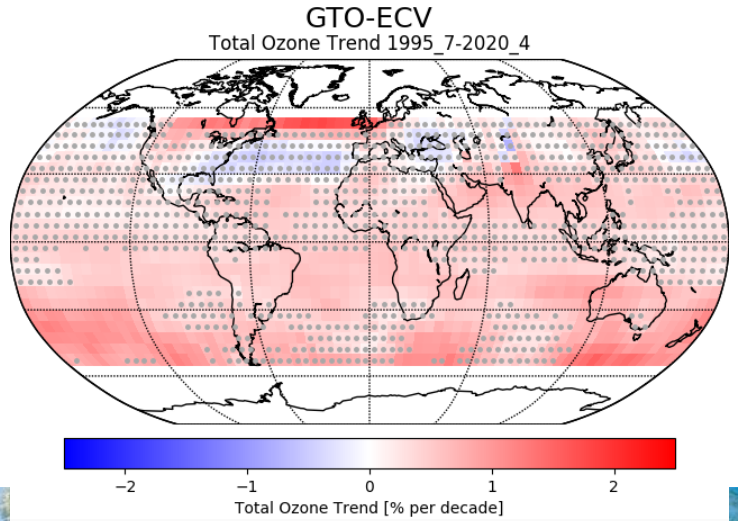

Update of Coldewey-Egbers et al., GRL, 2014