An Update on Trends in the Vertical Distribution of Ozone

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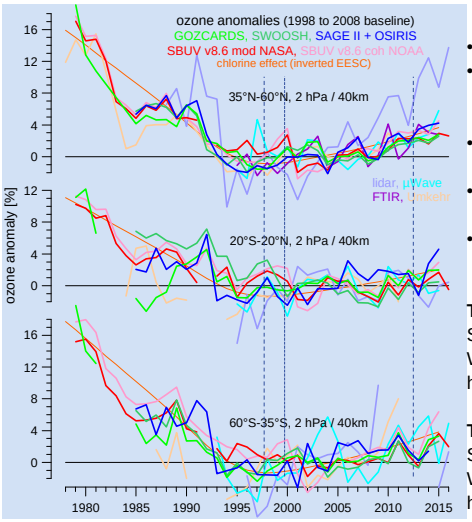
Summary

- *recent years confirm significant ozone increase in upper stratosphere*
- *observed magnitude + latitude-altitude pattern consistent with recovery*
- *no significant trends below 10 hPa / 30 km (as expected)*
- *SBUV-, MLS- and OSIRIS – based records give consistent picture*
- *ground-based records generally agree, but some outliers*
- *uncertainty margins of SI2N (Harris et al. 2015) very conservative*

time series, three latitude bands, upper stratosphere



Multiple linear regression

- monthly anomalies (%)
- fit hockey-stick (1997), QBO, F10.7, MEI, volcanic aerosol
- remove QBO, F10.7, MEI, volcanic aerosol
- fit linear trend (2000 to 2015/16)
- uncertainty from fit residuals, AR1 corrected

Trend period

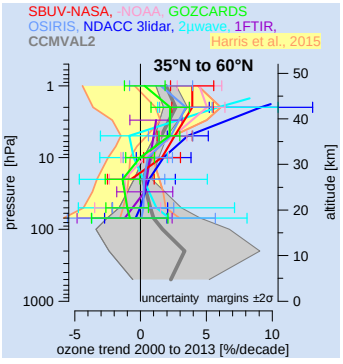
SI2N:	[1998,2012]
WMO 2014:	[2000,2013/4]
here:	[2000,2015/6]

Trend (2hPa, 35°N to 60°N)

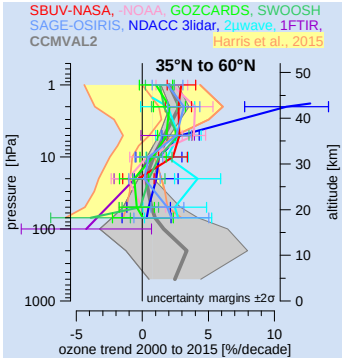
SI2N (J):	+1.3±4.8 %/dec
WMO 2014:	+3.9±1.3 %/dec
here (J,sat):	+2.7±1.8 %/dec

vertical profile of trends (35°N to 60°N)

as in WMO 2014, 2000 to 2013



updated until 2015/16, 2000 to 2015/16



"Recovery" near 2 hPa / 40 km

- all records show significant increase in upper stratosphere (≈2 hPa)
- additional years tighten results (expected ~$N^{-3/2}$)
- spread (of these records) smaller than SI2N uncertainty range, trend larger
- observed trends consistent with CCMVal2 simulations (2.7±1.8 vs. 2.8±0.7 %/dec)
- some station trends differ (lidar @ 2 hPa, FTIR @ 100 hPa, µWave @20 hPa)

References

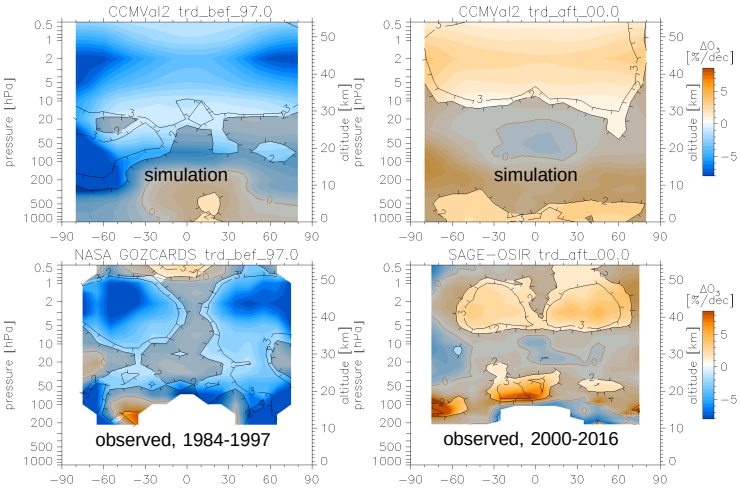
Harris, N.R.P., et al.: Past changes in the vertical distribution of ozone – Part 3: Analysis and interpretation of trends, *Atmos. Chem. Phys.*, **15**, 9965-9982, doi:10.5194/acp-15-9965-2015, 2015.

Hubert, D., et al.: Ground-based assessment of the bias and long-term stability of fourteen limb and occultation ozone profile data records, *Atmos. Meas. Tech.*, **9**, 2497-2534, doi:10.5194/amt-9-2497-2016, 2016.

WMO 2014: Pawson, S., Steinbrecht, W. et al.: Update on global ozone: Past, present, and future, Chapter 2 in: *Scientific Assessment of Ozone Depletion: 2014*, Global Ozone Research and Monitoring Project – Report No. 55, World Meteorological Organization, Geneva, Switzerland, 2014.

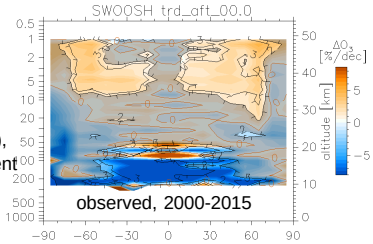
latitude - altitude pattern of ozone trends

„decline" 1980s to 1997	„recovery" 2000 to 2015/16

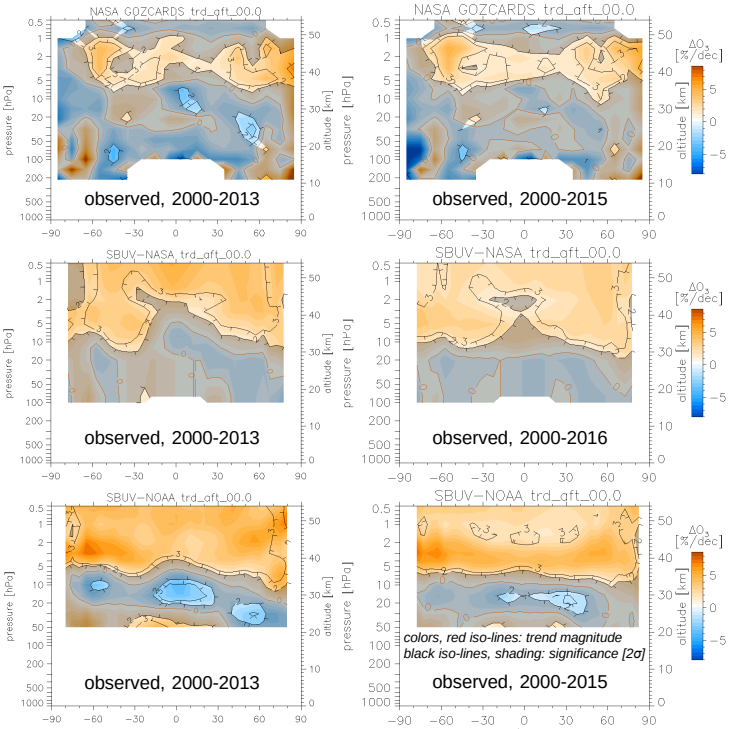


Trend patterns

- largest trends near 2 hPa, high latitudes
- post-2000 increase mirrors old decline
- no significant increase below 10 hPa
- recent years confirm WMO 2014
- OSIRIS, MLS (GOZCARDS, SWOOSH), and SBUV (NASA, NOAA) give consistent results



2000 to 2013 (=WMO 2014)



colors, red iso-lines: trend magnitude
black iso-lines, shading: significance [2σ]

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http://www.dwd.de/ozon