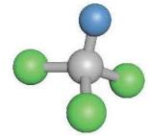
International Symposium On:
The Unexpected Increase in Emissions of Ozone-Depleting CFC-11
25-27 March 2019, Vienna, Austria



A note on possible effects of the unexpected increase in global CFC-11 to ozone profiles

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Motivation

- LOTUS: Long-term Ozone Trends and Uncertainties in the Stratosphere

Report published in 2019, and is included in the 2018 Ozone Assessment.

- LOTUS Phase 2: 2019-2020

Need to attribute trends to halogen chemistry vs other sources of variability (e.g. GHGs, dynamics), which was not attempted in LOTUS phase 1.

- Montzka et al. (2018) results on increased global CFC-11 emissions.

Outline

- Data sources and model simulations
- Stratospheric ozone trends from observations and model

    comparisons at individual lidar stations

- Effect of halogen chemistry on stratospheric ozone trends

    studies with Chemical Transport Model (CTM) simulations

- Effect of increased CFC-11 on future ozone profile trends

    studies with Chemistry Climate Model (CCM) simulations

Data Sources

- Long-term LIDAR ozone data at 5 stations (1998-2016) residing in the northern mid-latitudes, the tropics and the southern mid-latitudes.

Station	Latitude	Longitude	Elevation	**Starting years**
Hohenpeissenberg	47.8 °N	11.0 °E	975 m	**1987**
Haute Provence	43.9 °N	5.7 °E	674 m	**1985**
Table Mountain	34.4 °N	117.7 °W	2200 m	**1992**
Mauna Loa	19.5 °N	155.6 °W	3405 m	**1993**
Lauder	45.0 °S	169.7 °E	370 m	**1994**

- SBUV v8.6 satellite overpass ozone data at 5 lidar stations (1998-2016, total and profile)
- Natural proxies considered to affect ozone variability:

  Quasi Biennial Oscillation (QBO), Solar flux (F10.7), El Nino Southern Oscillation (ENSO), Arctic Oscillation/Antarctic Oscillation (AO/AAO), Tropopause pressure (from NCEP reanalysis), Aerosol Optical Depth (AOD)

- Trends are derived after removing seasonal and other natural variability

Model simulations

- Ozone simulations with the **Chemical Transport Model** (Oslo CTM3) (period 1998-2016)

    Two runs performed:

    a) run with full chemistry

    b) run with halogens fixed at 1998 levels

- Ozone simulations with the coupled **Chemistry Climate Model** (CCM) EMAC (period 2002-2050)

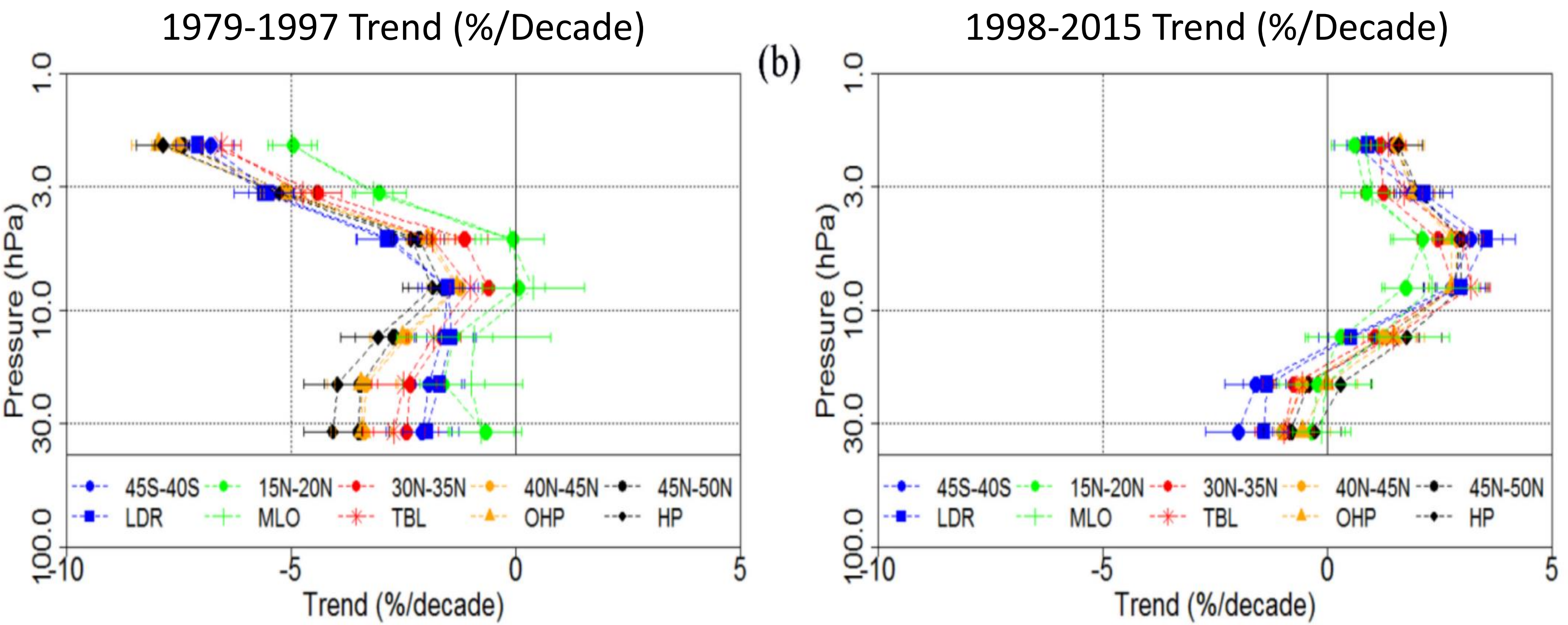
    Two runs performed:

    a) Reference run: Free-running simulation where CFC-11 declines by about 50% until 2050

    b) Sensitivity run with CFC-11 fixed at 2002 levels, i.e. no CFC-11 decline (Dameris et al., ACPD, 2019)

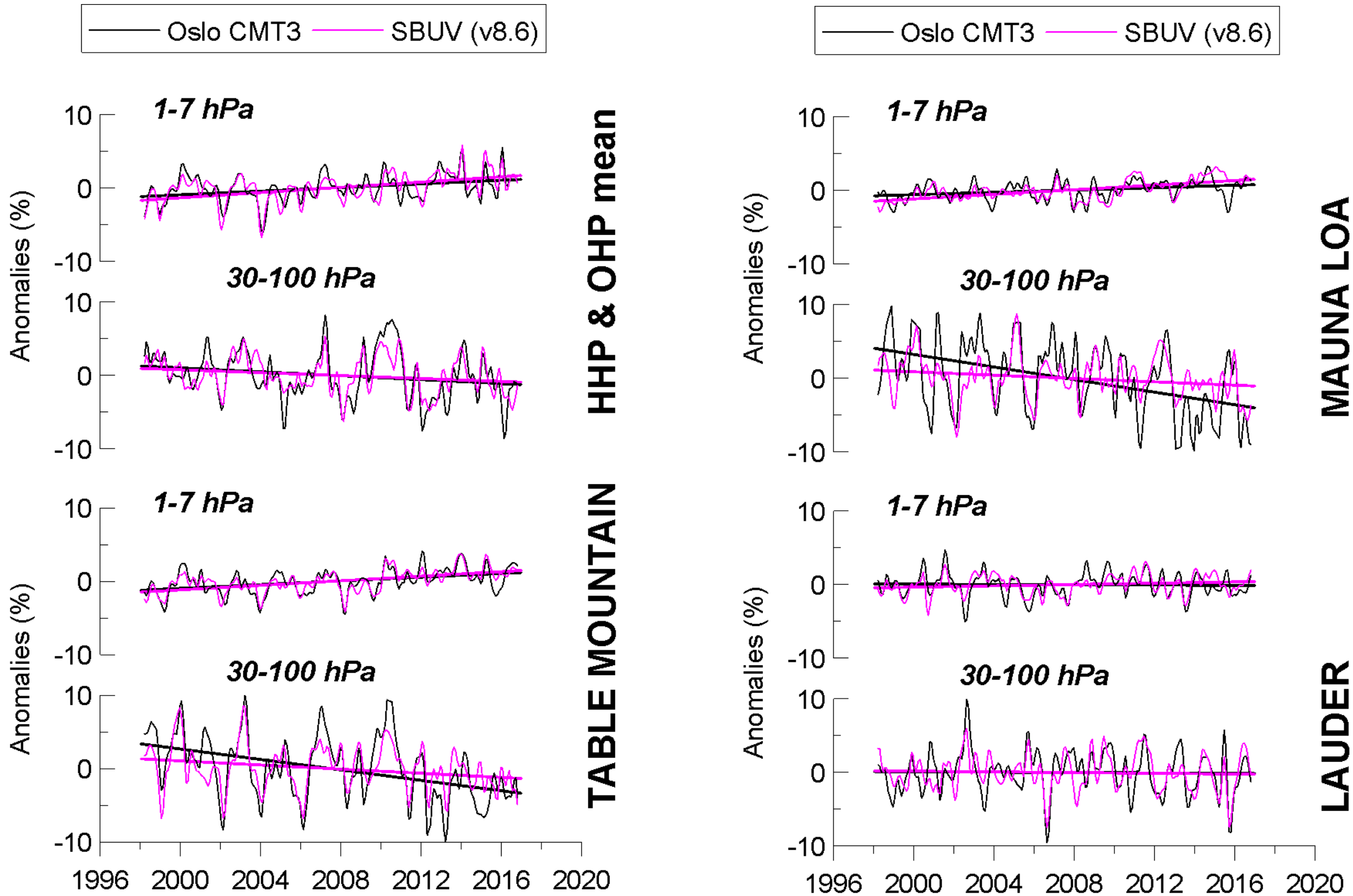
Sampling Issues: Consistency of Zonal Mean Trends to Single Location Trends (LOTUS phase 1)

Compare trends from SBUV MOD overpass to trends in relevant 5° zonal average at five lidar stations: LDR=Lauder; MLO=Mauna Loa; TBL=Table Mountain; OHP=Haute Provence; HP=Hohenpeissenberg).



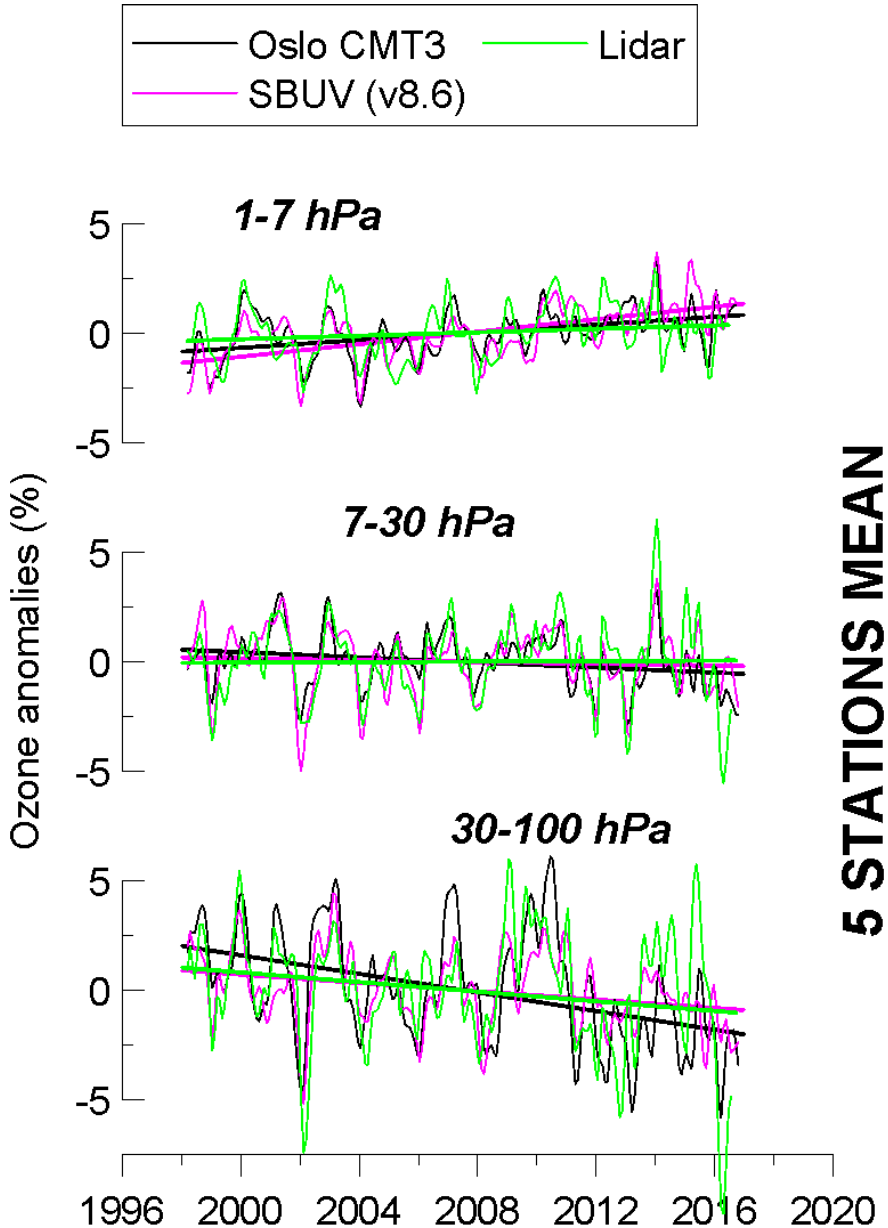
Adapted from Figure 7 of Zerefos et al., ACP, 2018

Current Study: Stratospheric ozone trends (observed and modelled) at individual lidar stations



- Model runs indicate an increase in ozone in the upper stratosphere above 7 hPa and a decrease in the lower stratosphere between 30 and 100 hPa.
- Very good agreement with SBUV (v8.6) satellite data.

Current Study: Comparison with lidar measurements

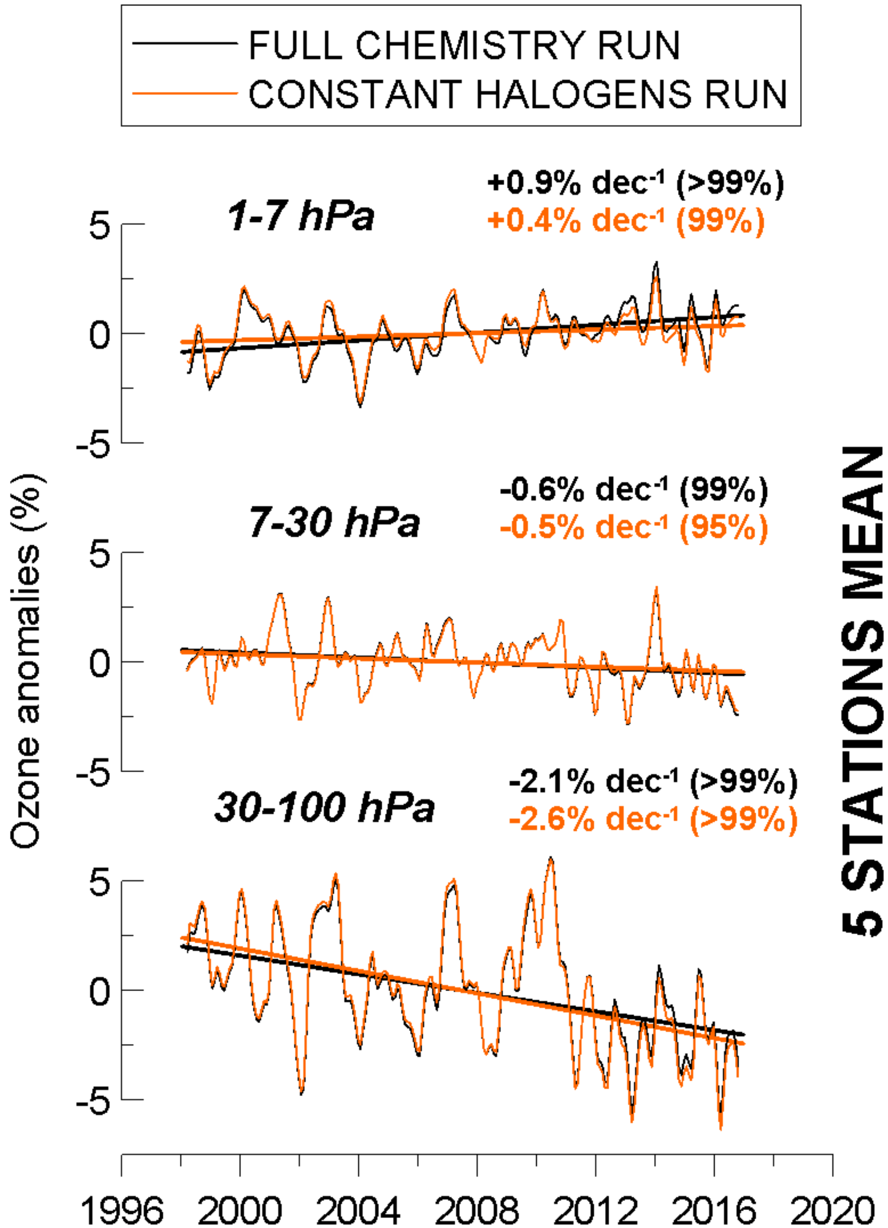


Oslo chemical transport model (CTM3) data correlate well both with Lidar measurements and SBUV observations

Correla-tions	Model vs SBUV	Model vs Lidar
1-7hPa	0.70*	0.49*
7-30hPa	0.81*	0.78*
30-100hPa	0.70*	0.54*

* 99.9% confidence level

Current Study: Effect of chemistry on stratospheric ozone trends



Oslo chemical transport model (CTM3) data (1998-2016)

Two runs performed:

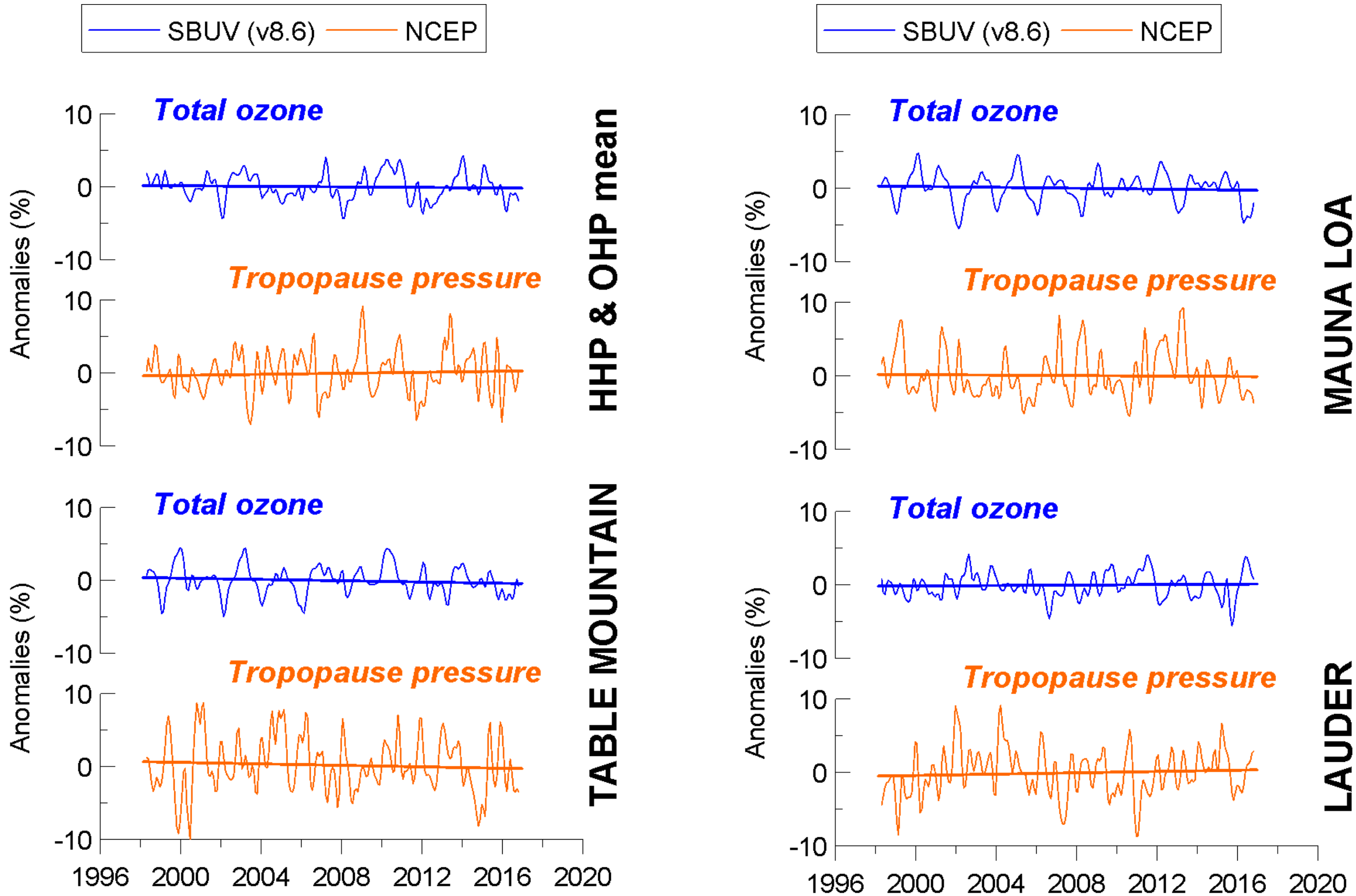
a) run with full chemistry

b) run with constant halogens at 1998 levels

Difference in trends between the two runs is 0.5% per decade in the upper and lower stratosphere, and almost zero in the middle stratosphere.

CTM3 indicates that the reduction of halogens after 1997 explains about 55% of the upward trend in the upper stratospheric ozone (1-7 hPa), and about 24% in the lower stratospheric ozone (30-100 hPa).

Current Study: Total ozone and tropopause pressure trends at individual lidar stations



- Opposing trends in the vertical distribution resulted to insignificant trends in total ozone after 1997.
- Reanalysis data from NCEP reveal insignificant trends in tropopause pressures as well.

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Discussion started: 18 March 2019

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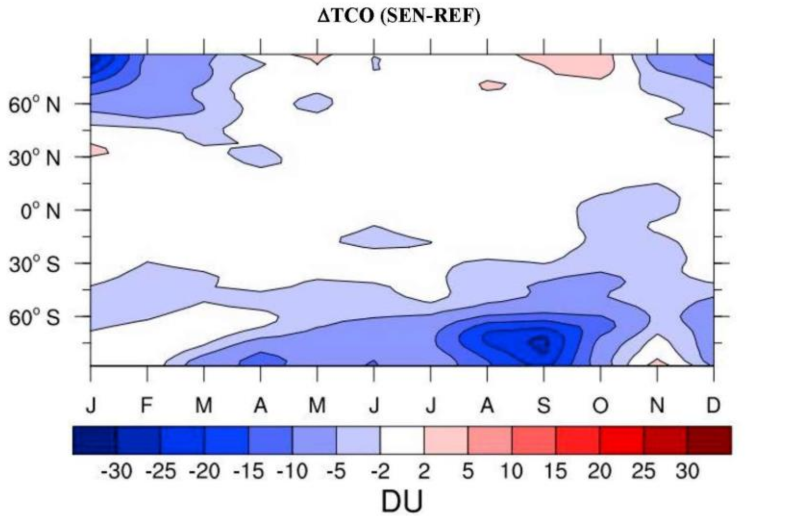
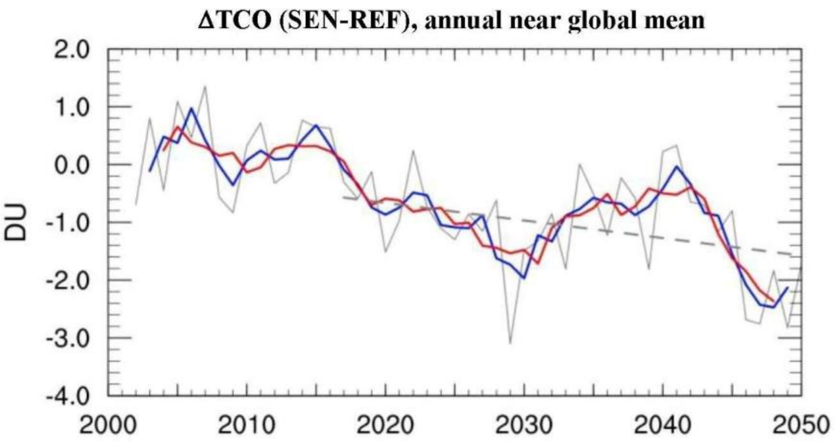




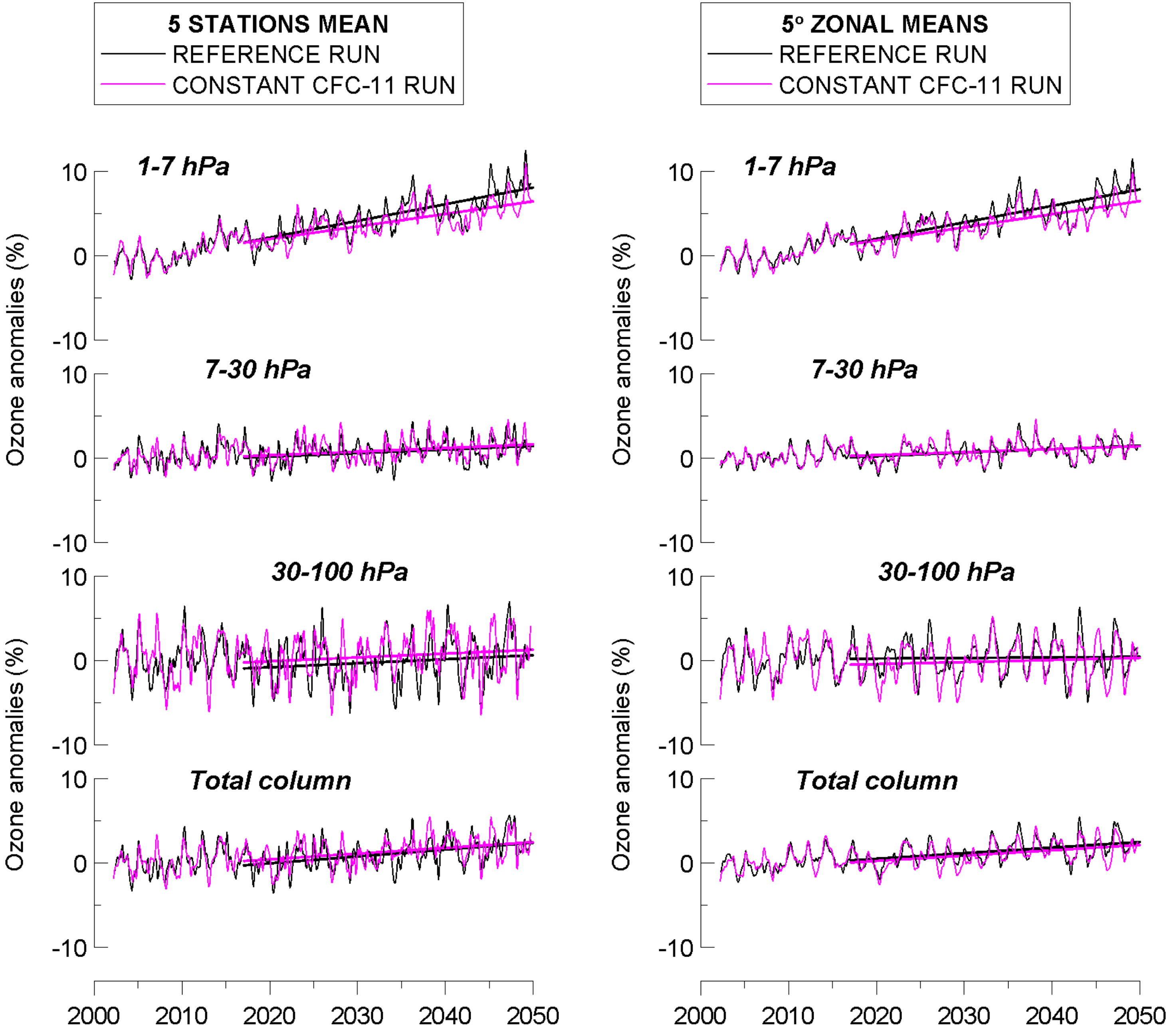
Dameris et al., ACPD, 2019

A Chemistry-Climate Model (CCM) study is performed, investigating the consequences of a constant CFC-11 surface mixing ratio for stratospheric ozone in future.

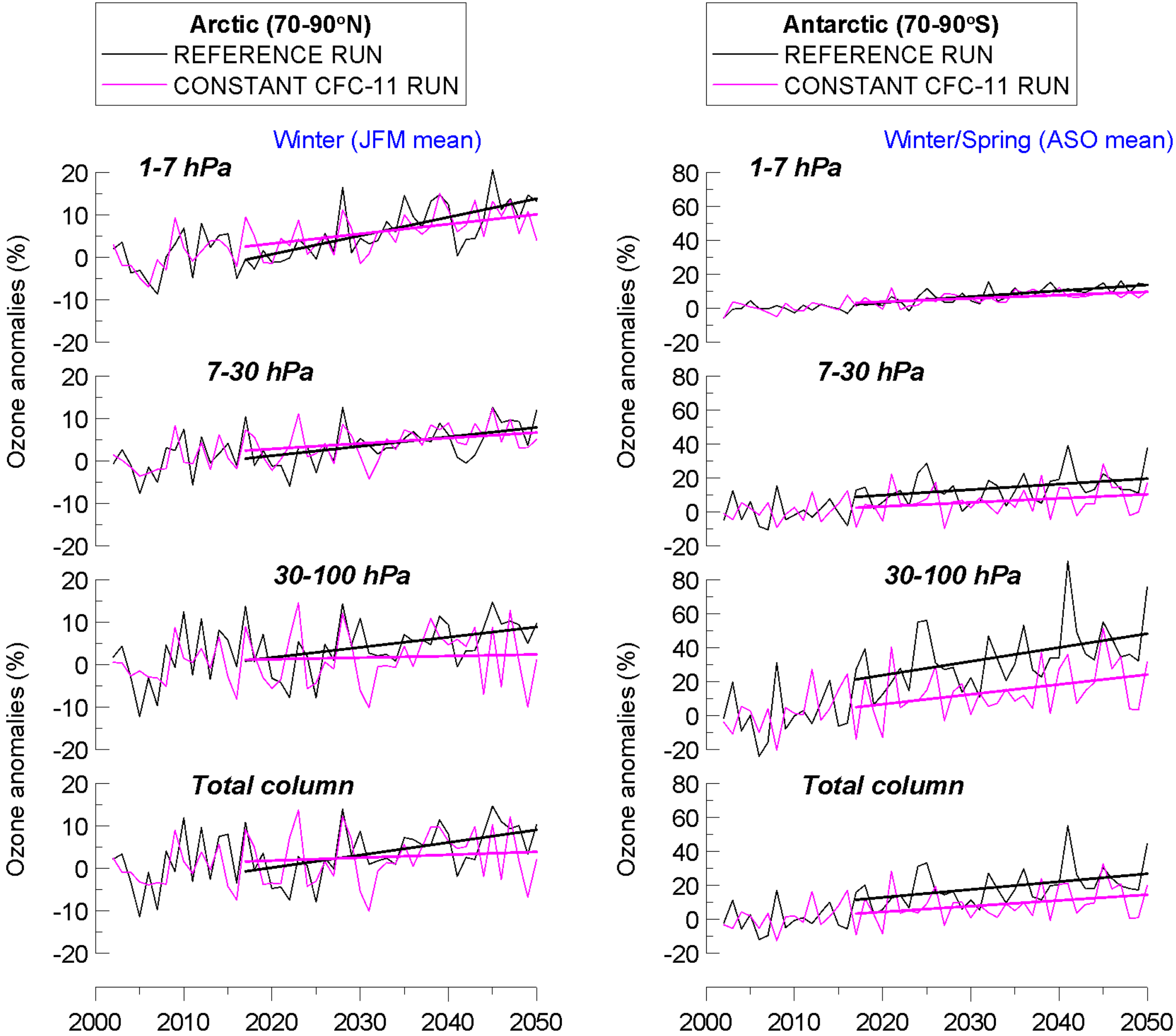
Two runs performed:
a) Reference run: Free-running simulation where CFC-11 declines by 50% from 2002 to 2050
b) Sensitivity run with CFC-11 fixed at 2002 levels, i.e. no decline

The total column ozone is in particular affected in both polar regions in winter and spring.

Current Study: Effect of CFC-11 on profile/total column ozone trends



Current Study: Effect of CFC-11 on profile/total column ozone trends



Summary

- It is confirmed from observations (lidar, SBUV) that we do not see yet a signal in ozone profiles following the increase of CFC-11 emissions since 2012.
- We expect the effect of Halogens reduction to be maximized at 1-7 hPa at lidar stations, as shown by chemical transport model simulations since 1998.
- We expect the effect of increased CFC-11 to be clearly seen after 2040 particularly in the poles, as shown by chemical climate model simulations.

Acknowledgements

LOTUS

LONG-TERM OZONE TRENDS AND UNCERTAINTIES IN THE STRATOSPHERE

PANACEA

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