Stratospheric ozone: past, present, observations

Giorgio S. Taverna, Martyn Chipperfield, Wuhu Feng
ICAS, University of Leeds, UK

The ozone layer

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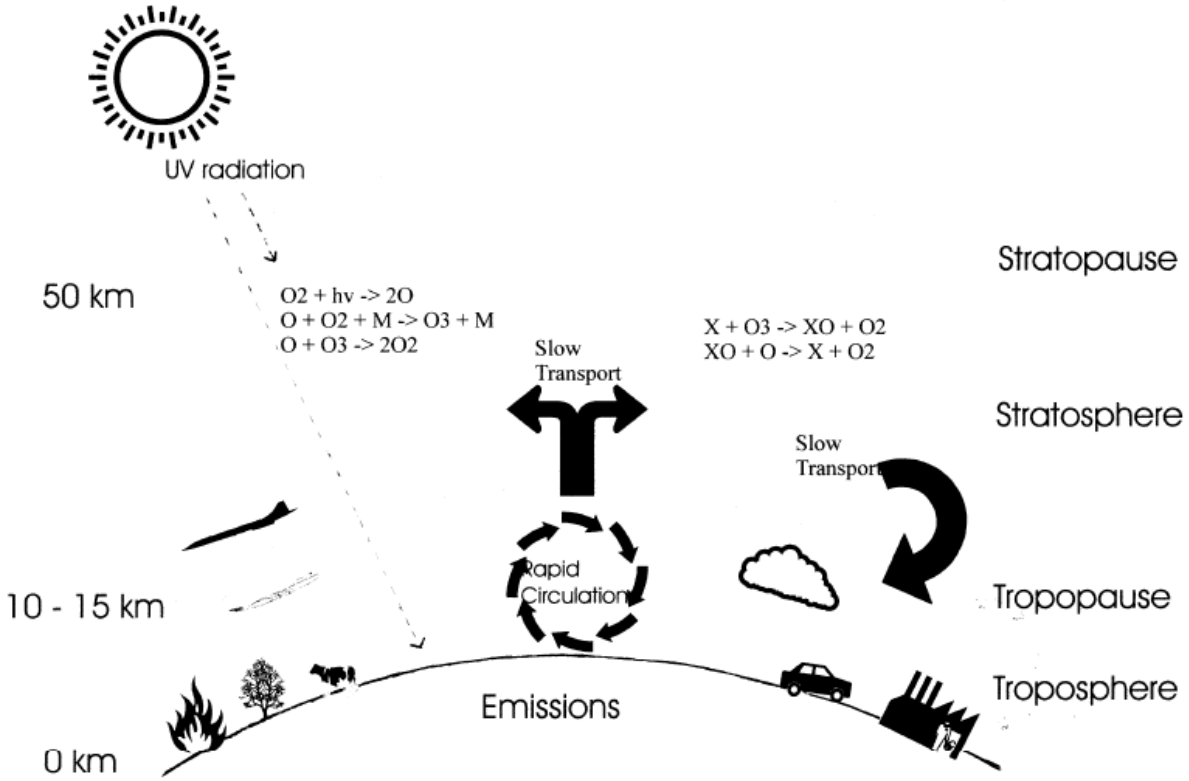
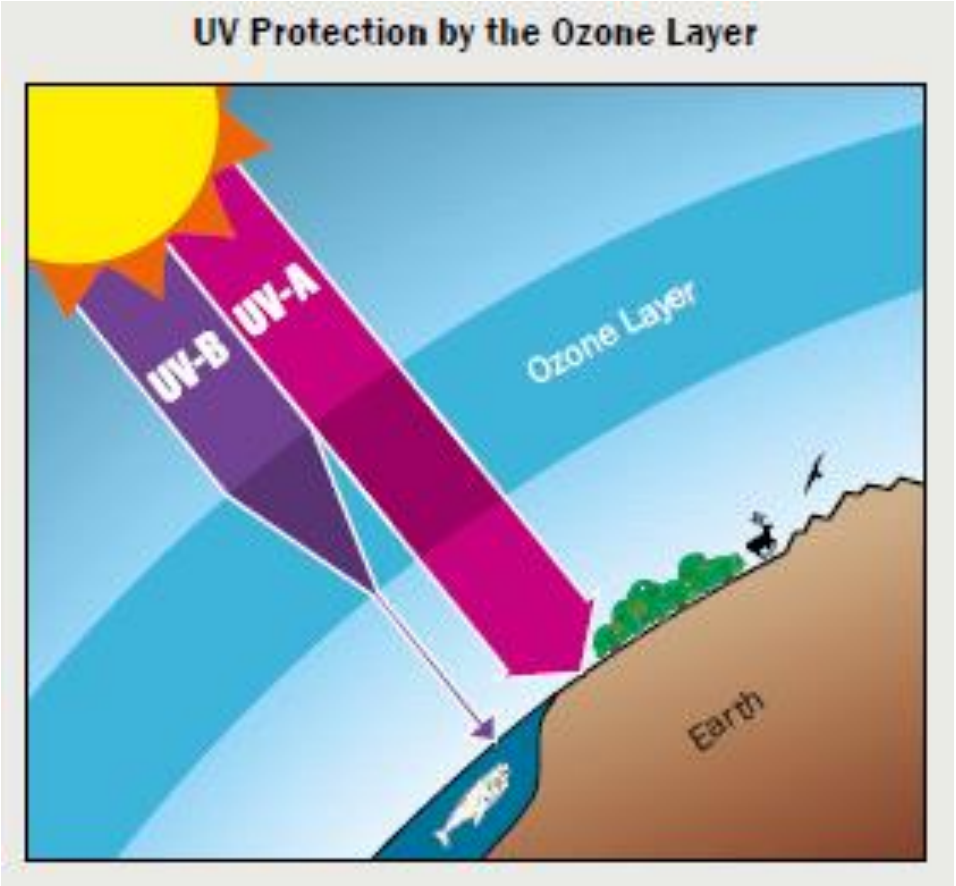
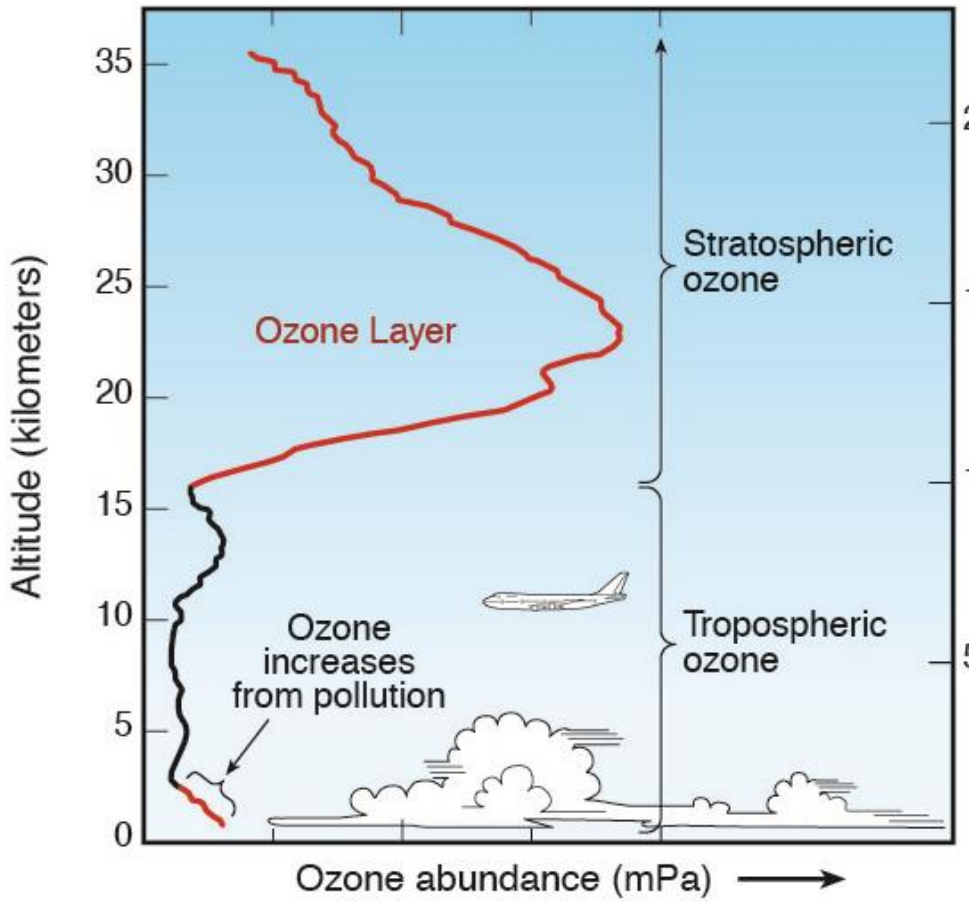
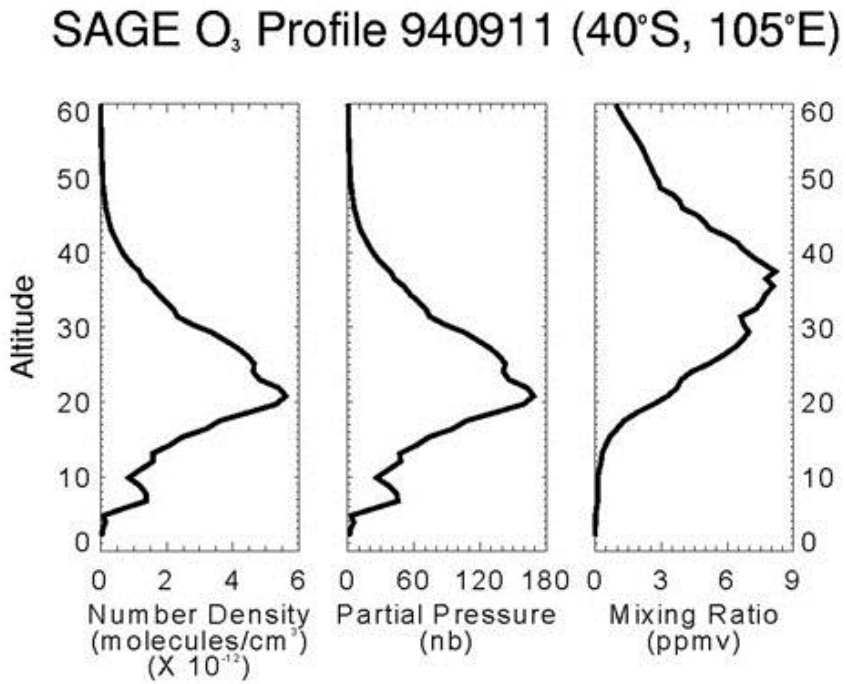
What is ozone and why is so important?





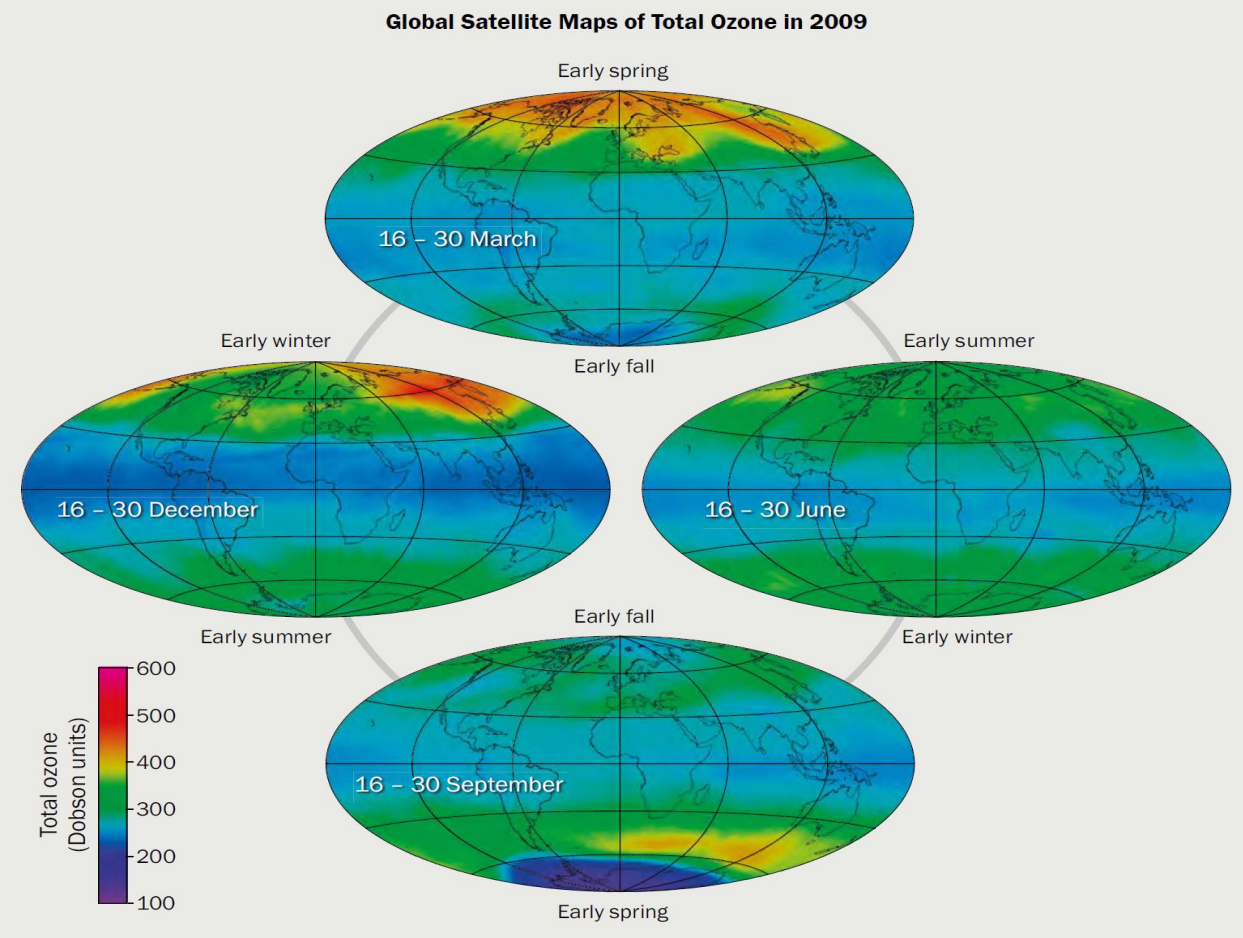
The ozone layer

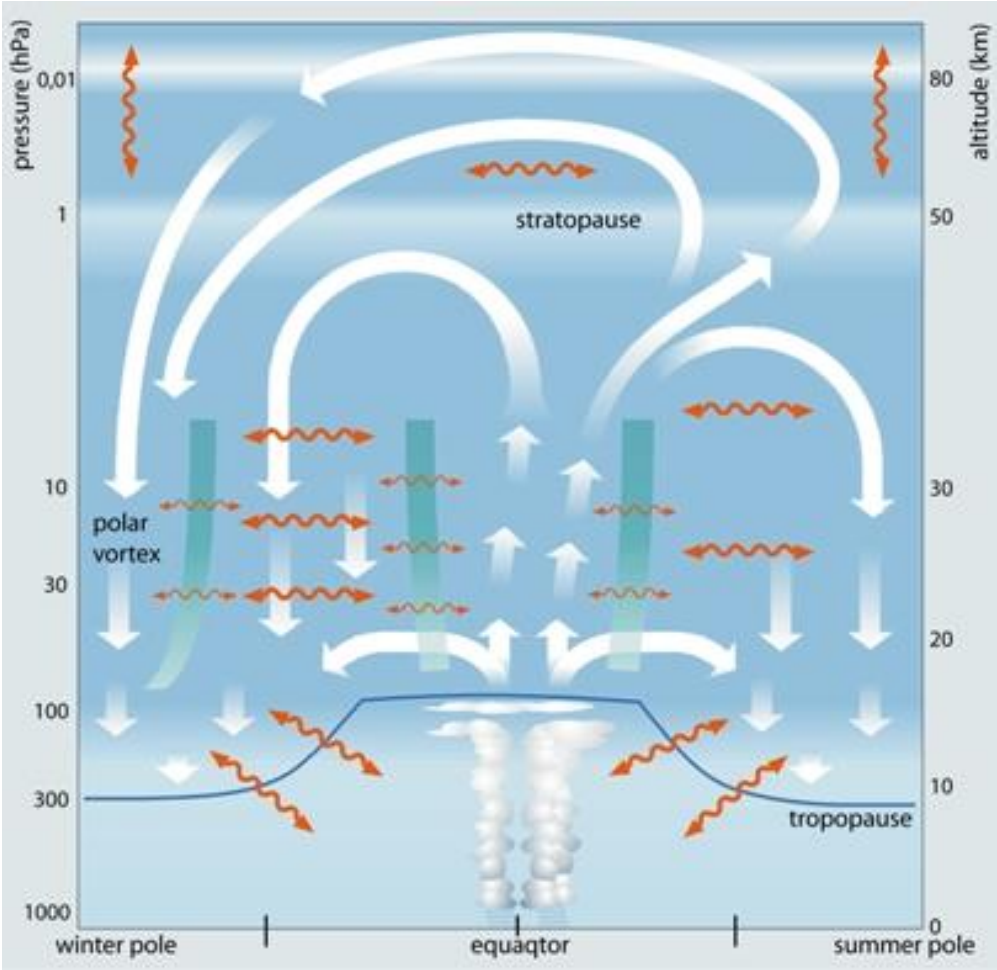




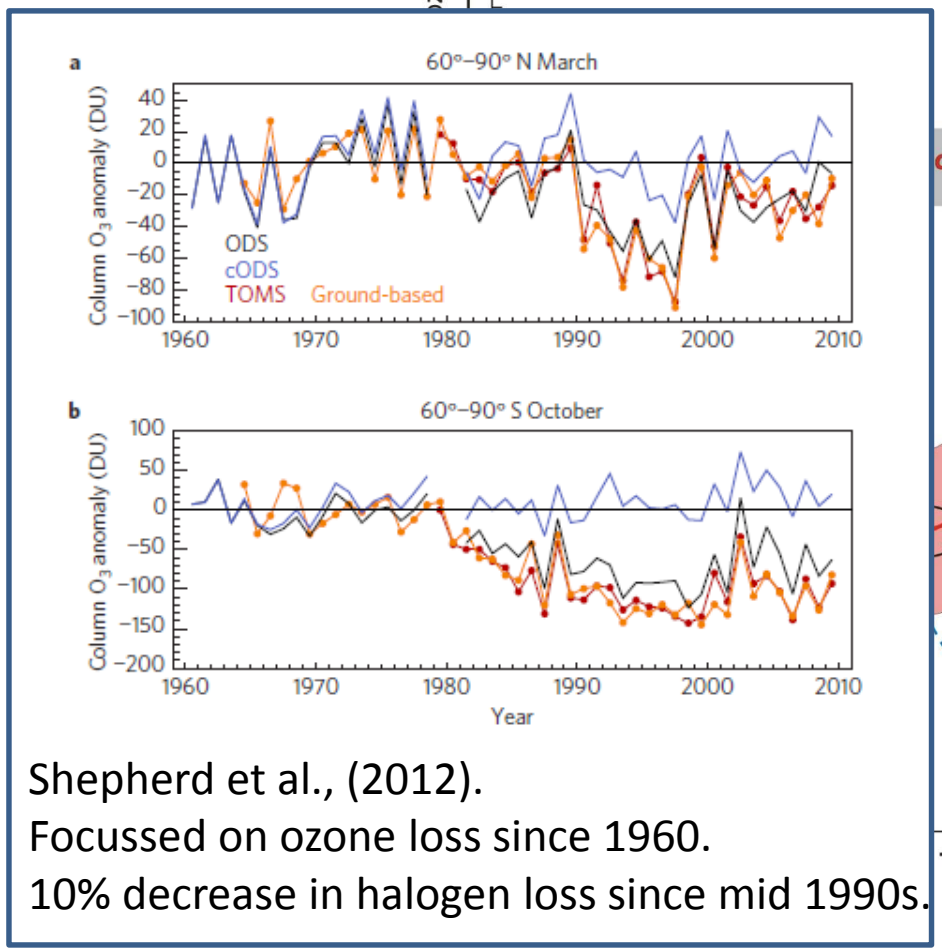
Satellite profile in different units

The ozone layer





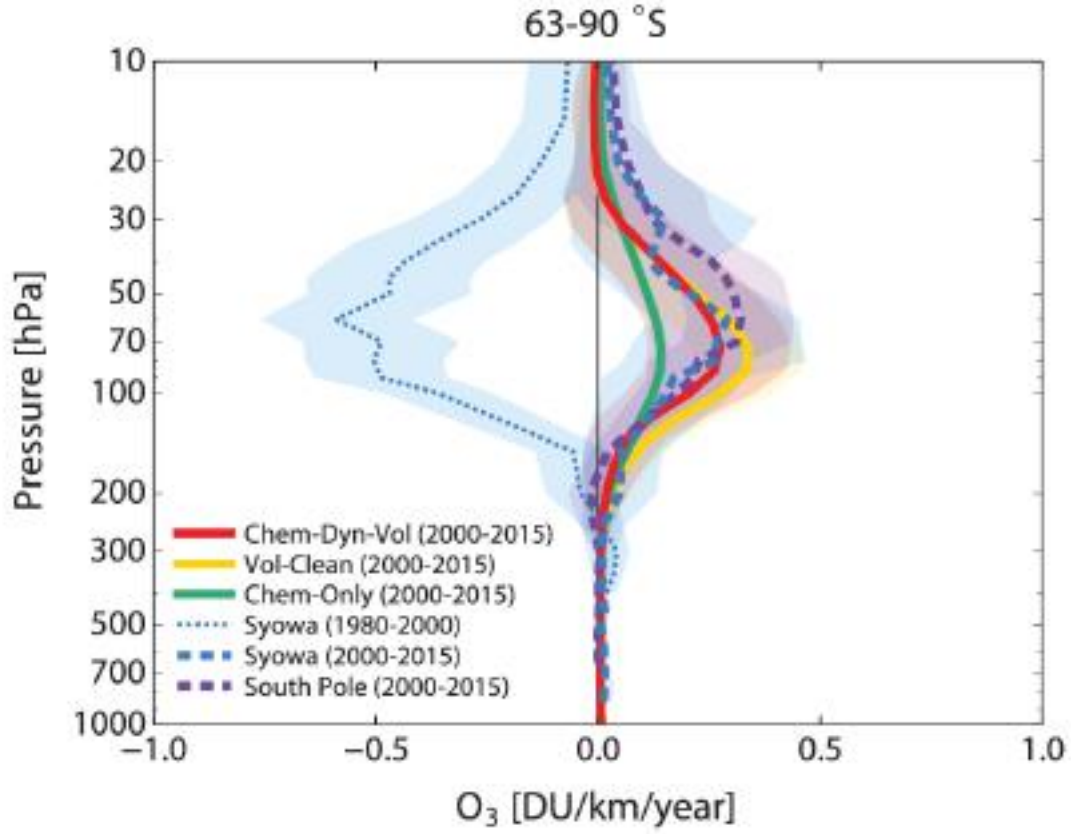
Ozone Depletion and Recovery



Shepherd et al., (2012).
Focussed on ozone loss since 1960.
10% decrease in halogen loss since mid 1990s.

Solomon et al., 2016

Observations and 3-D model show 'recovery' in Antarctic ozone loss rates.



TOMCAT/SLIMCAT 3-D Model

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Model setup:

- Detailed stratospheric chemistry scheme. Specified aerosol SAD (3λ).
- Forced by ECMWF ERA-Interim winds and temperatures (no feedback).
- 1955 – 2015 (repeating 1980 meteorology before 1980)
- 2.8º x 2.8º. 32 levels: surface – 60 km.

Six simulations:

- Control. Forced by observed surface mixing ratios of long-lived ODSs (CFCs, HCFCs, solvents, CH_3Cl…)
- fODS 1960. ODSs fixed at 1960 tropospheric vmr
- fODS 1980.
- fODS 1995. (Peak tropospheric halogen: chlorine + α×bromine).
- World avoided: 3%/year growth in ODS emissions after 1987.
- Repeating 1980 meteorology.

Carbon Tetrachloric

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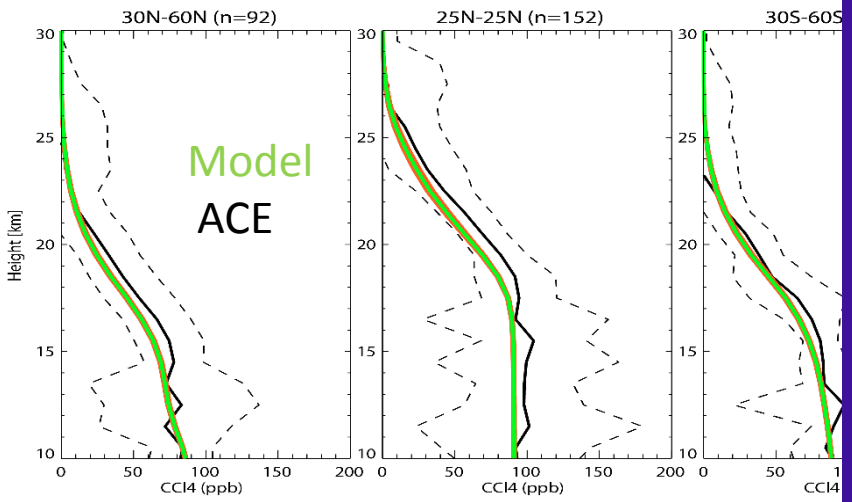
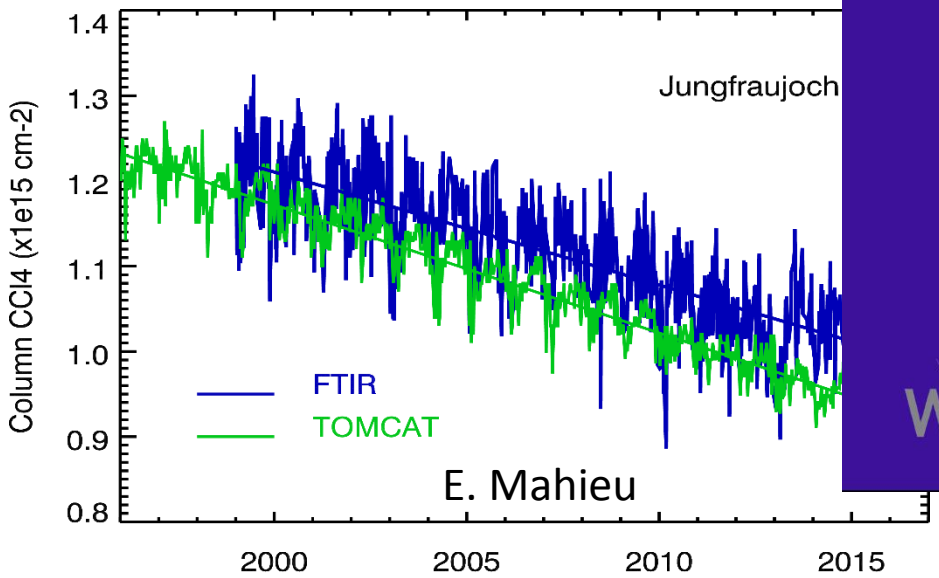
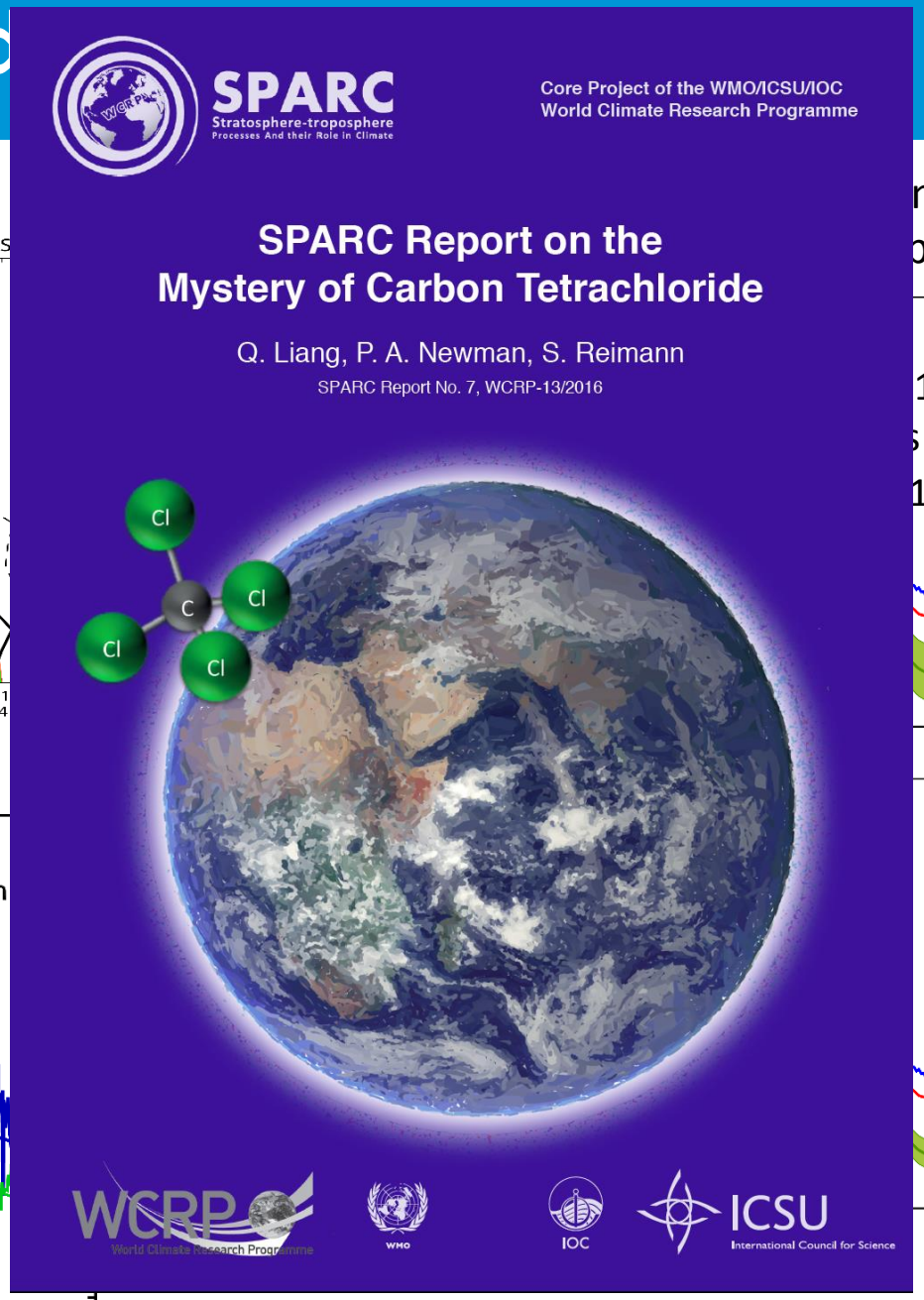
Comparison to ACE satellite profiles

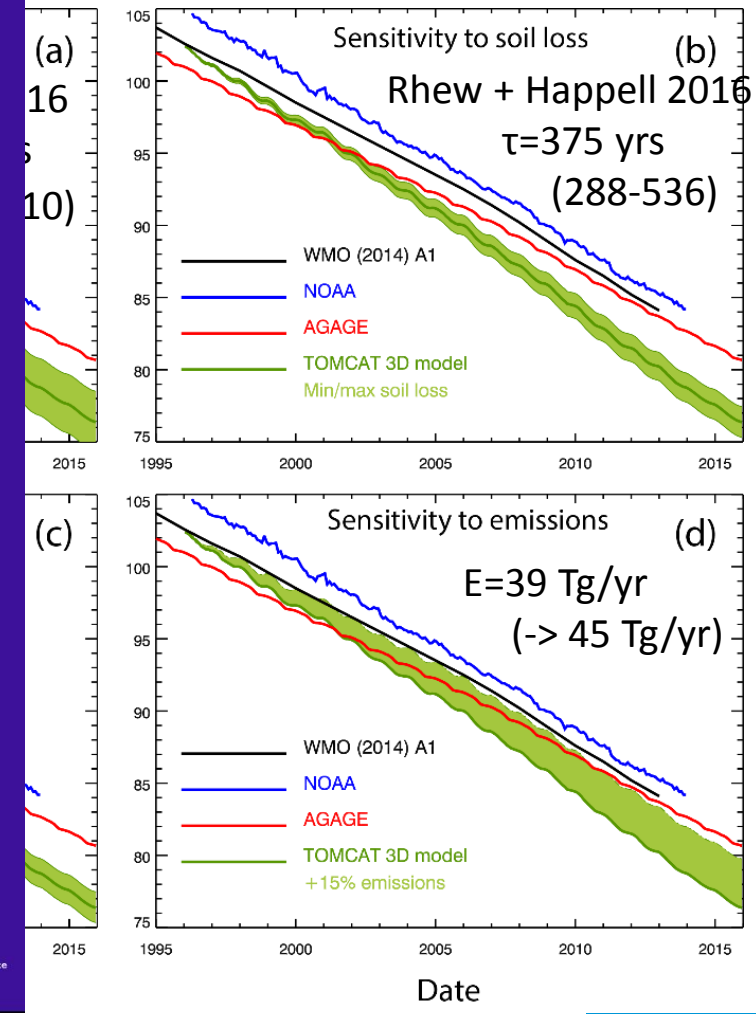


Column FTIR observations





n surface data (AGAGE and NOAA) rocesses and emissions



Overall model τ=32 yrs

Chipperfield et al., ACP, 2016

Hydrogen Fluoride

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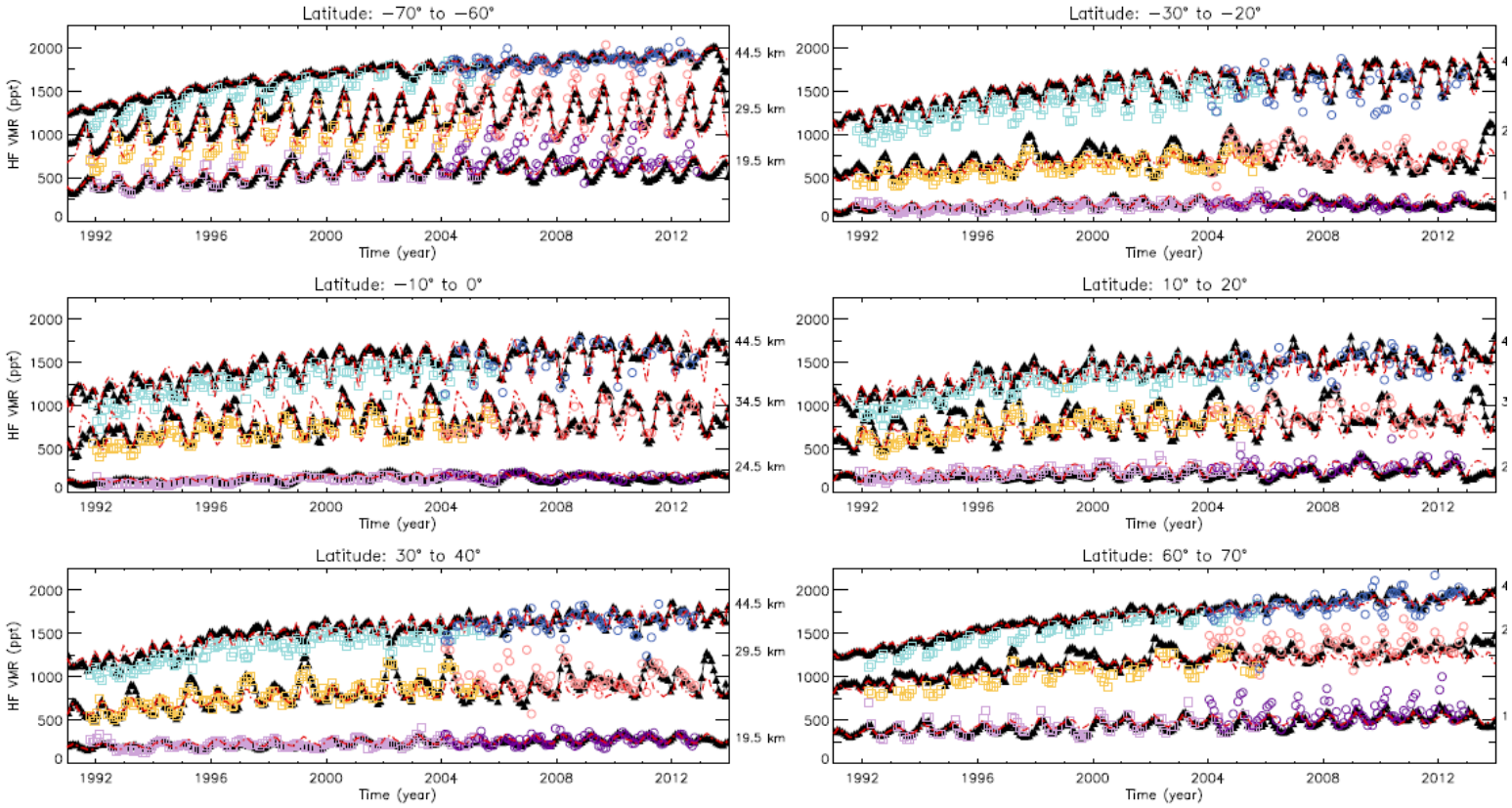
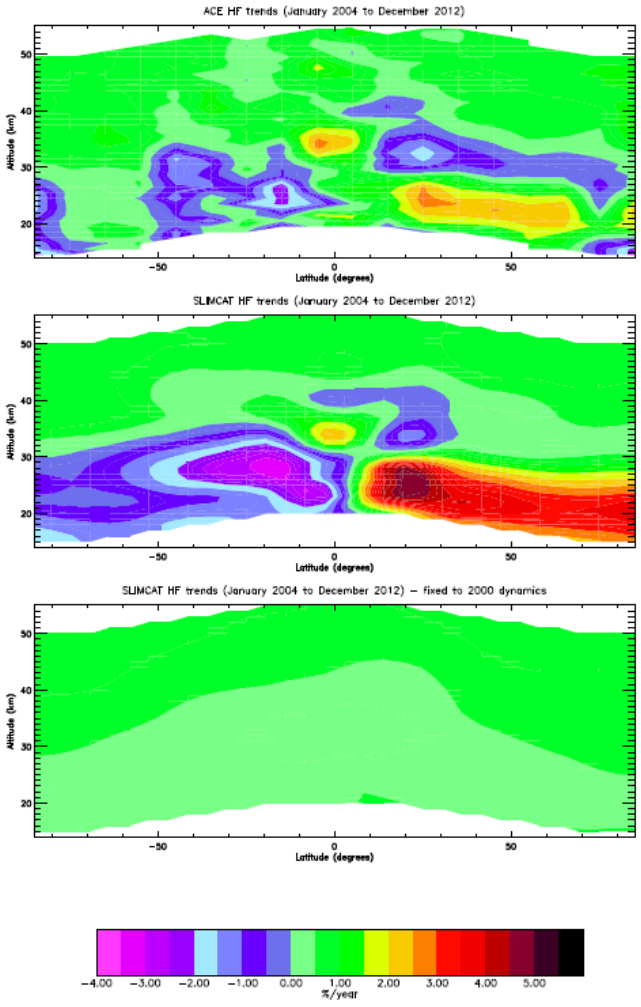
- Ultimate degradation product for all F in CFCs, HCFCS etc.
- Good stratospheric tracer.

HALOE + ACE satellites versus model (1991-2012)



Trends in growth of HF (%/yr) 2004-2012.



ACE

Model

Model: repeating winds

Harrison et al., ACP, 2016

Long-term change in column ozone

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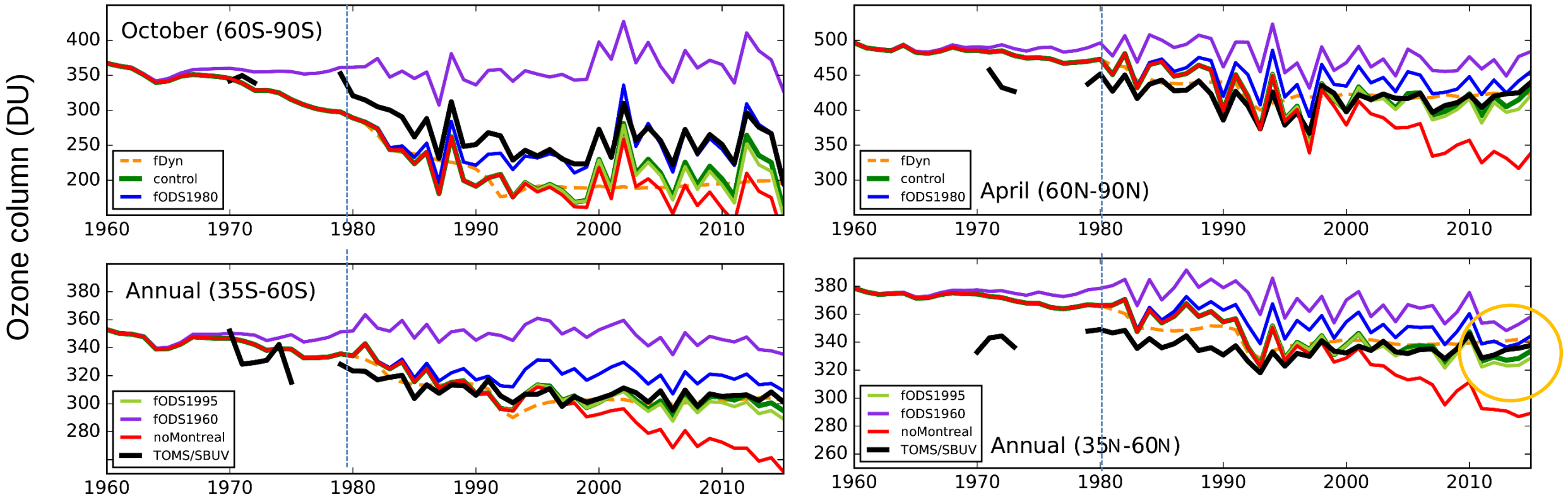
Column ozone (DU) from model sensitivity runs



Nb model used repeating 1980 winds before 1980

Long-term change in ozone profile

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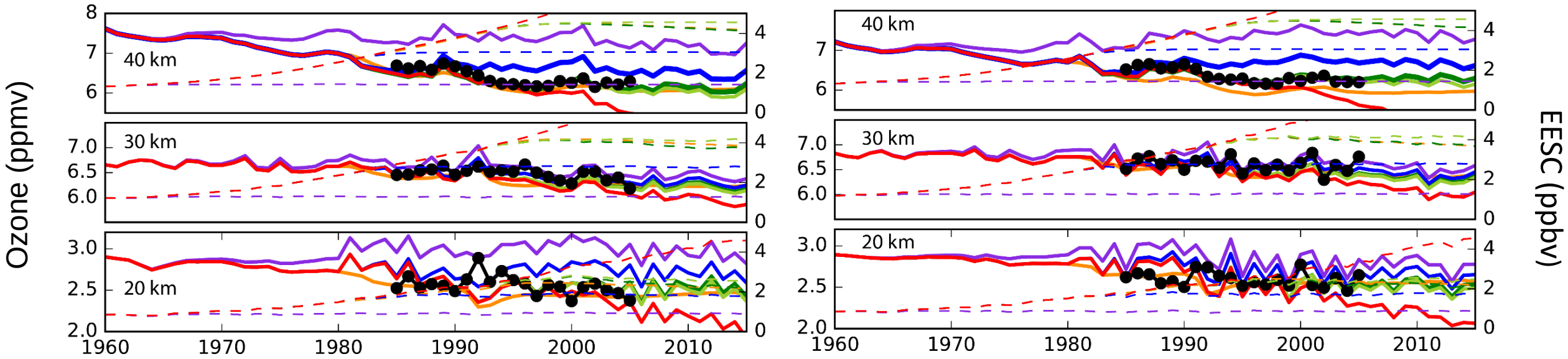
Ozone (ppmv) and EESC (ppbv) from model sensitivity runs



SAGE v7 data (bias corrected at 30 km and above)

Quantifying Ozone Loss and recovery

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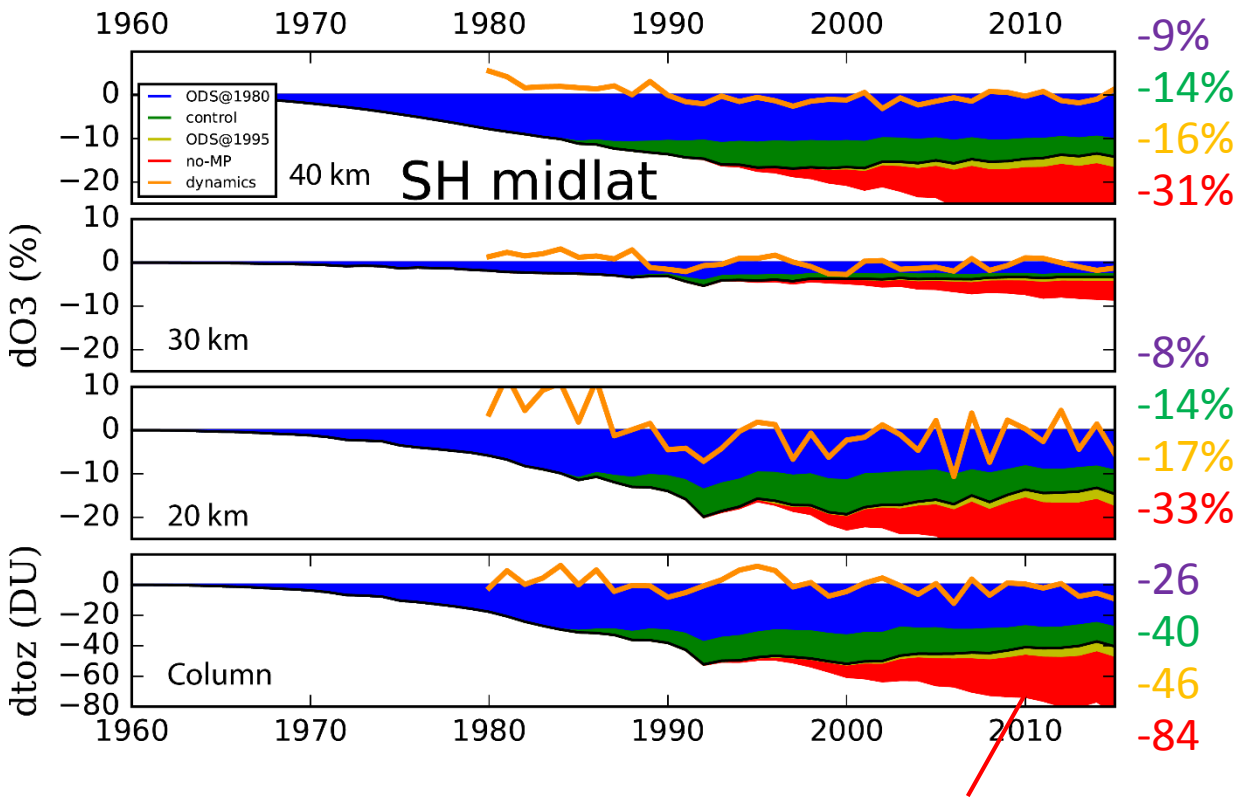
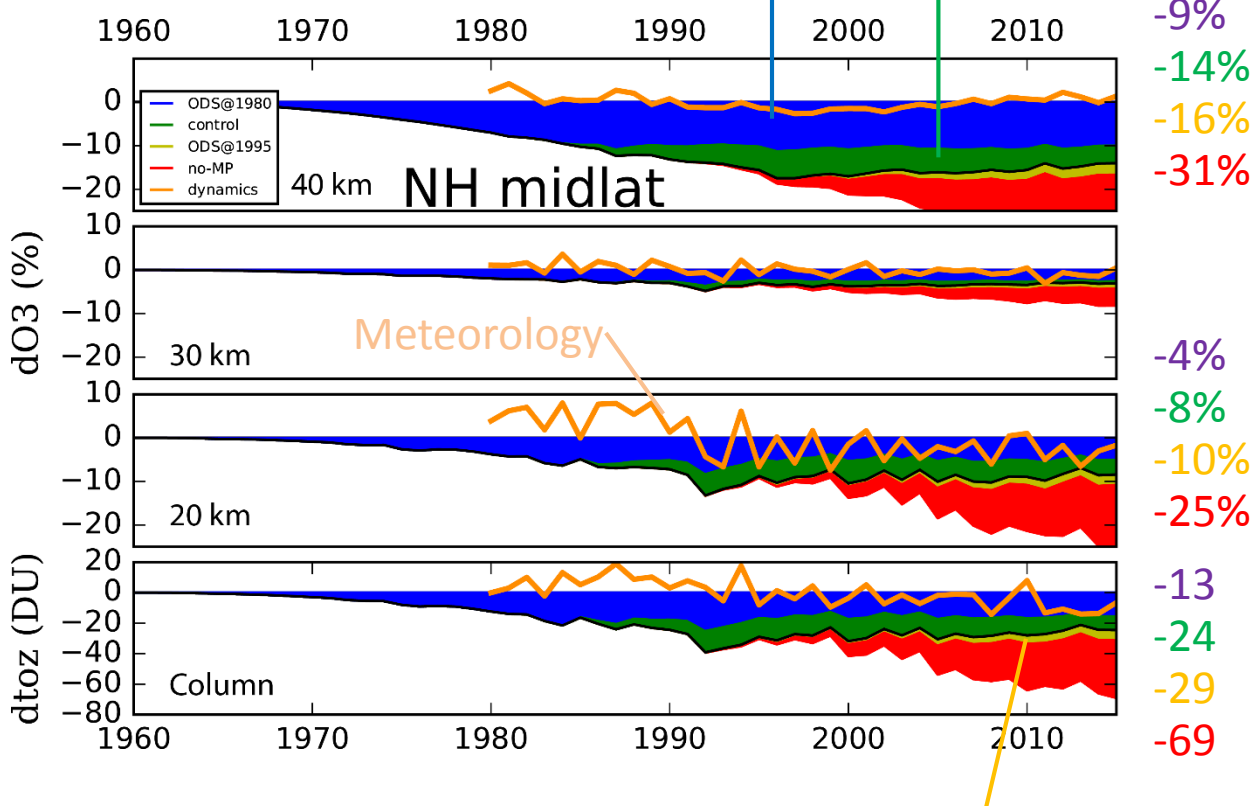
Contributions to modelled ozone depletion since 1960



Actual depletion = blue + green



Theoretical 'world avoided' = red

Recovery since peak halogens = orange

Decrease in ozone depletion from 1996 to 2015: 2% at 40 km, 2-3% at 20 km, 5-6 DU in column

Polar regions

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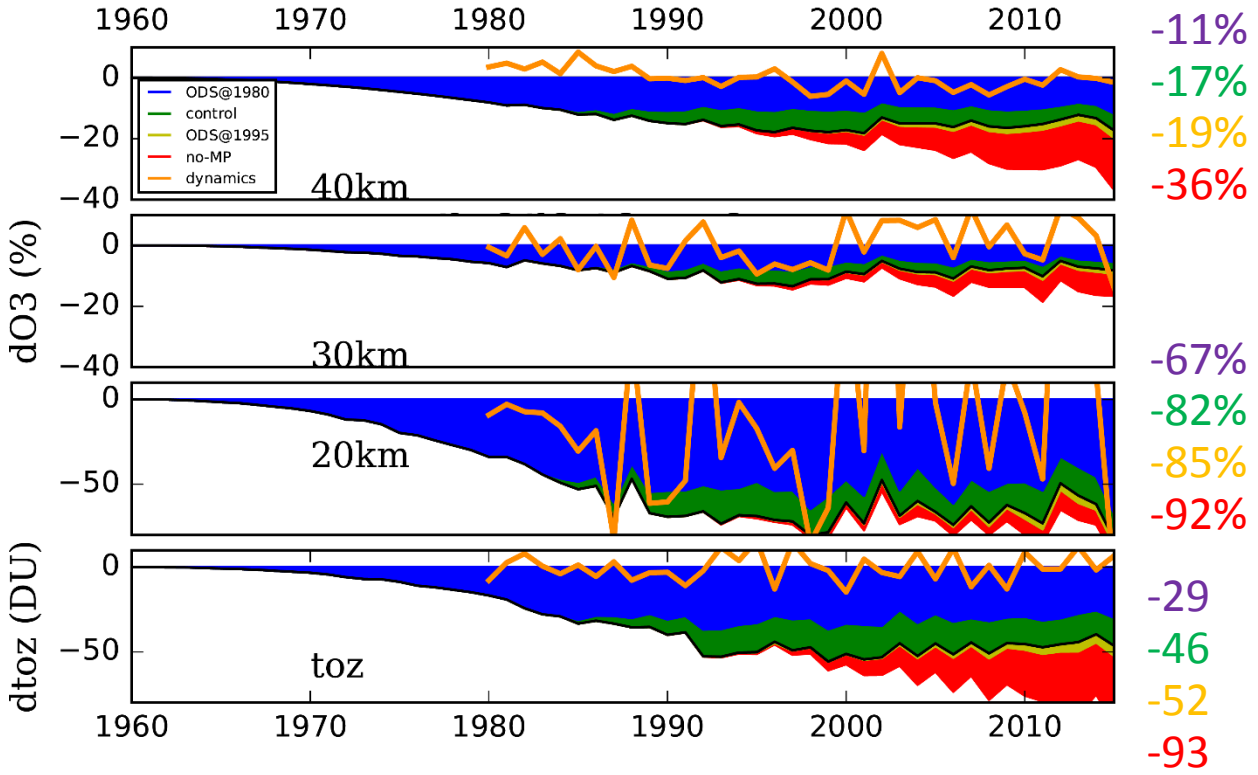
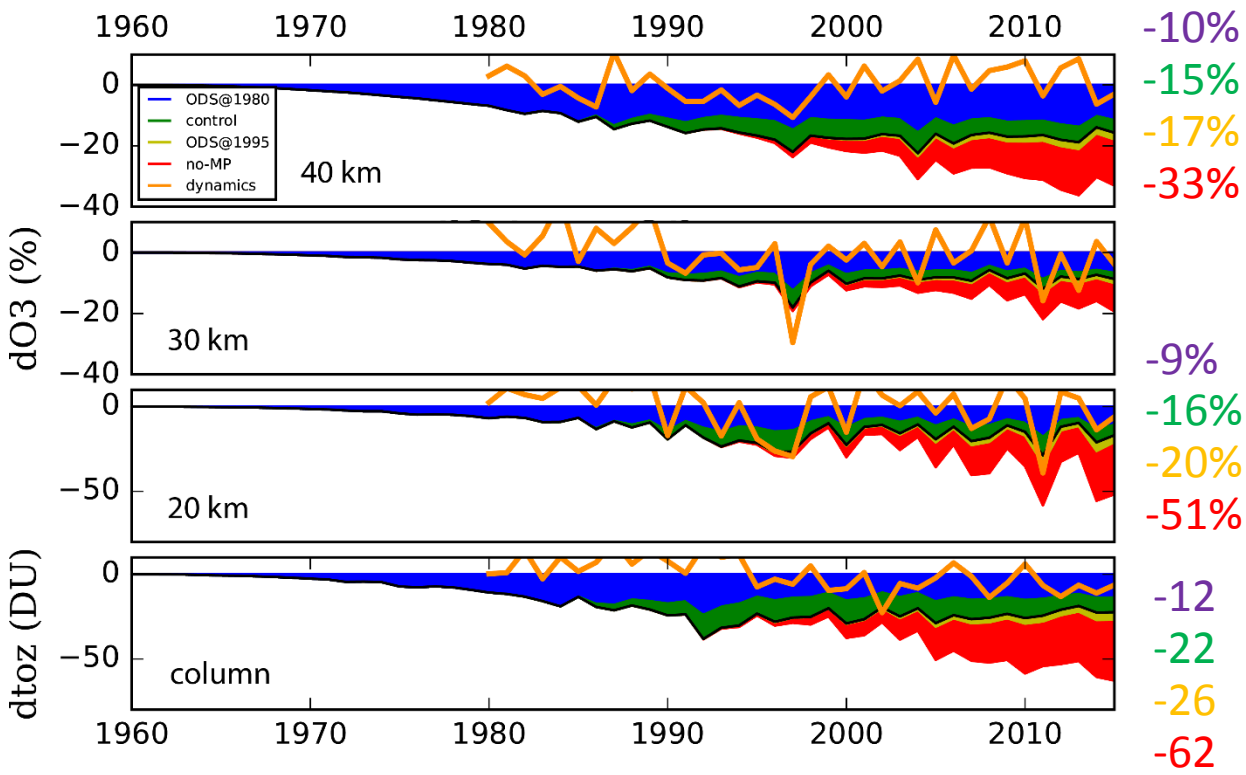
Contributions to modelled ozone depletion since 1960



SH October

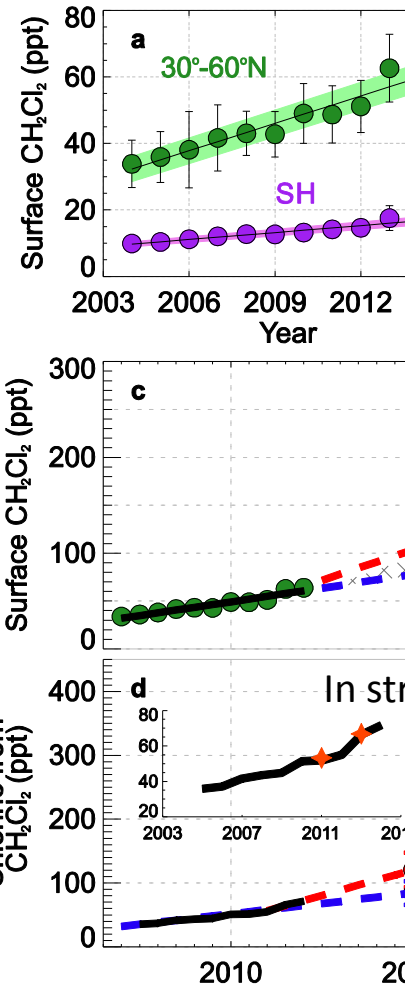


NH March

Decrease in ozone depletion from 1996 to 2015: 2% at 40 km, 3-4% at 20 km, 4-6 DU in column

Short-lived anthropogenic chlorine

Large and unexp
(NOAA data – St



Direct observations of enhanced CH_2Cl_2 in the UT over SE Asia.

Leedham Elvidge et al. ACP, (2015).

1948 E. C. Leedham Elvidge et al.: Increasing atmospheric concentrations of dichloromethane, CH_2Cl_2 1998–2012

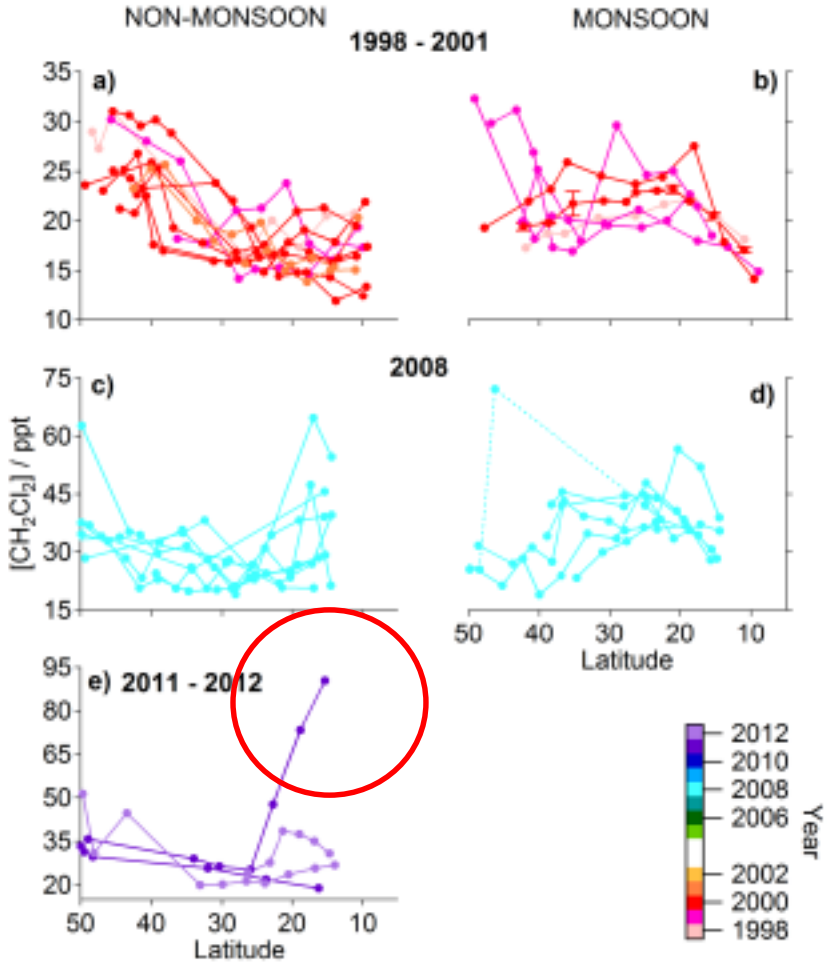
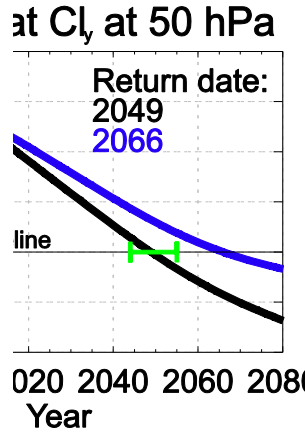


Figure 4. Latitudinal distributions of CH_2Cl_2 observed during flights to India for non-monsoon months on the left and monsoon months (July, August, September) on the right where colour = year (see inset colour bar; colour scale is consistent with Figs. 2, 4 and 6). Where multiple measurements of the same sample have been made 1σ error bars are given, see Sect. 2.



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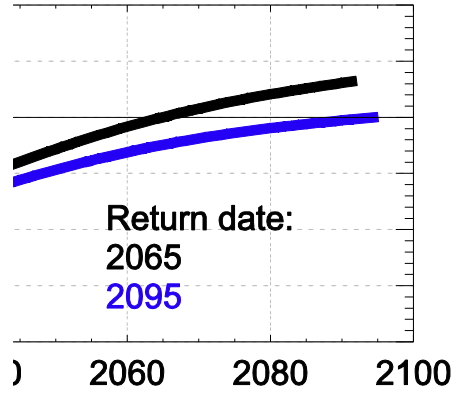
ation feedback)

r column O_3



See poster by Ryan Hossaini

Summary

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- Understanding of CCl_4 budget improved (SPARC report). Uncertainty in ocean loss and modelled stratospheric lifetime (transport) large factors in remaining uncertainty.
- Modelled ozone change since 1996 due to decreasing ODSs is modest. Difficult to separate from variability and climate effects. Can nonetheless say recovery ‘is on track’.
- Observations show large abundances of anthropogenic CH_2Cl_2 which is not controlled by the Montreal Protocol. Currently contributes ~100 pptv to stratospheric Cly. Continued increase could have an impact on timescale for ozone return dates.

Δozone versus ΔEESC

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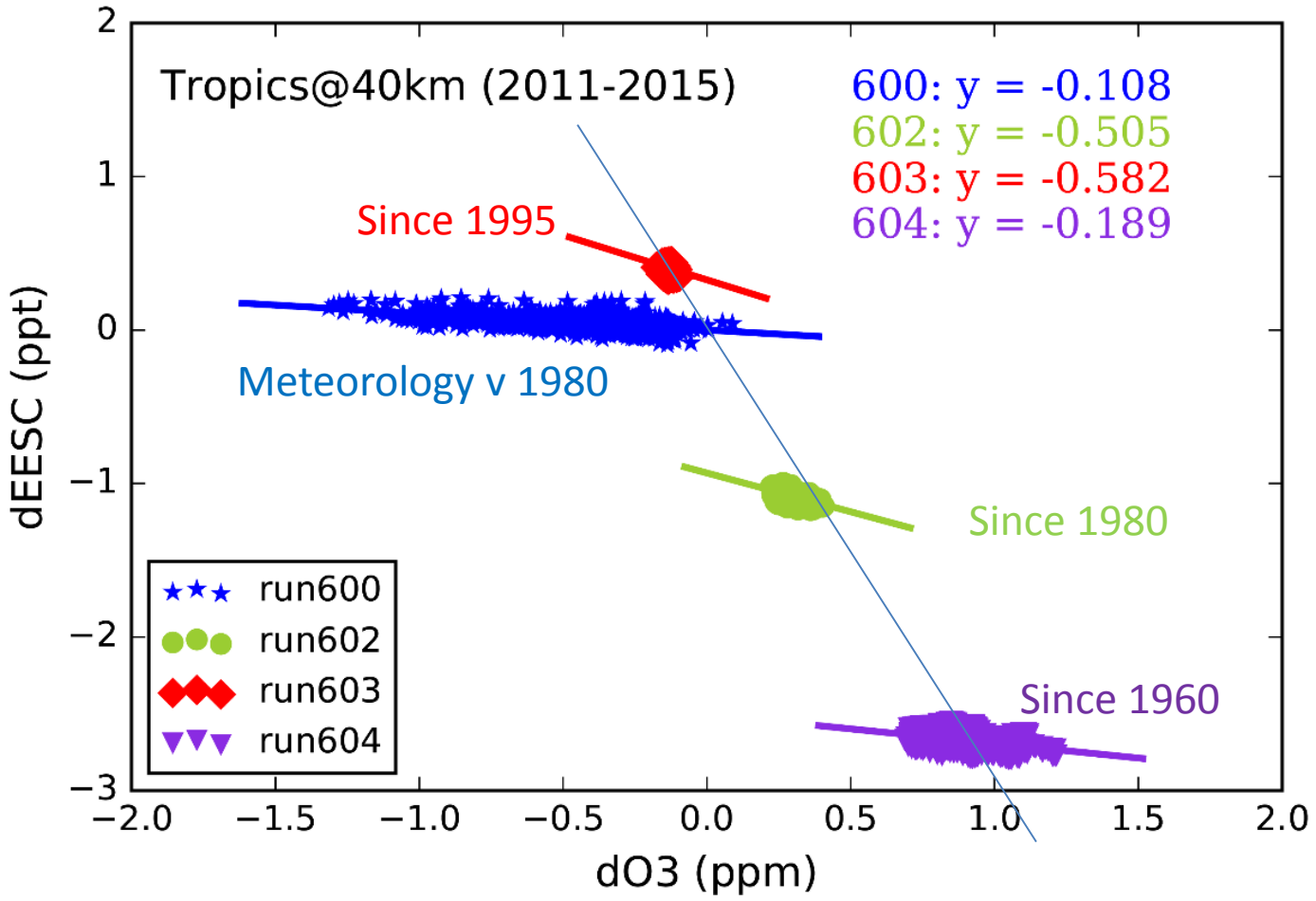

Polar regions