Stratospheric Ozone and the Montreal Protocol

WMO / UNEP Ozone Assessment 2014
Chapter 2

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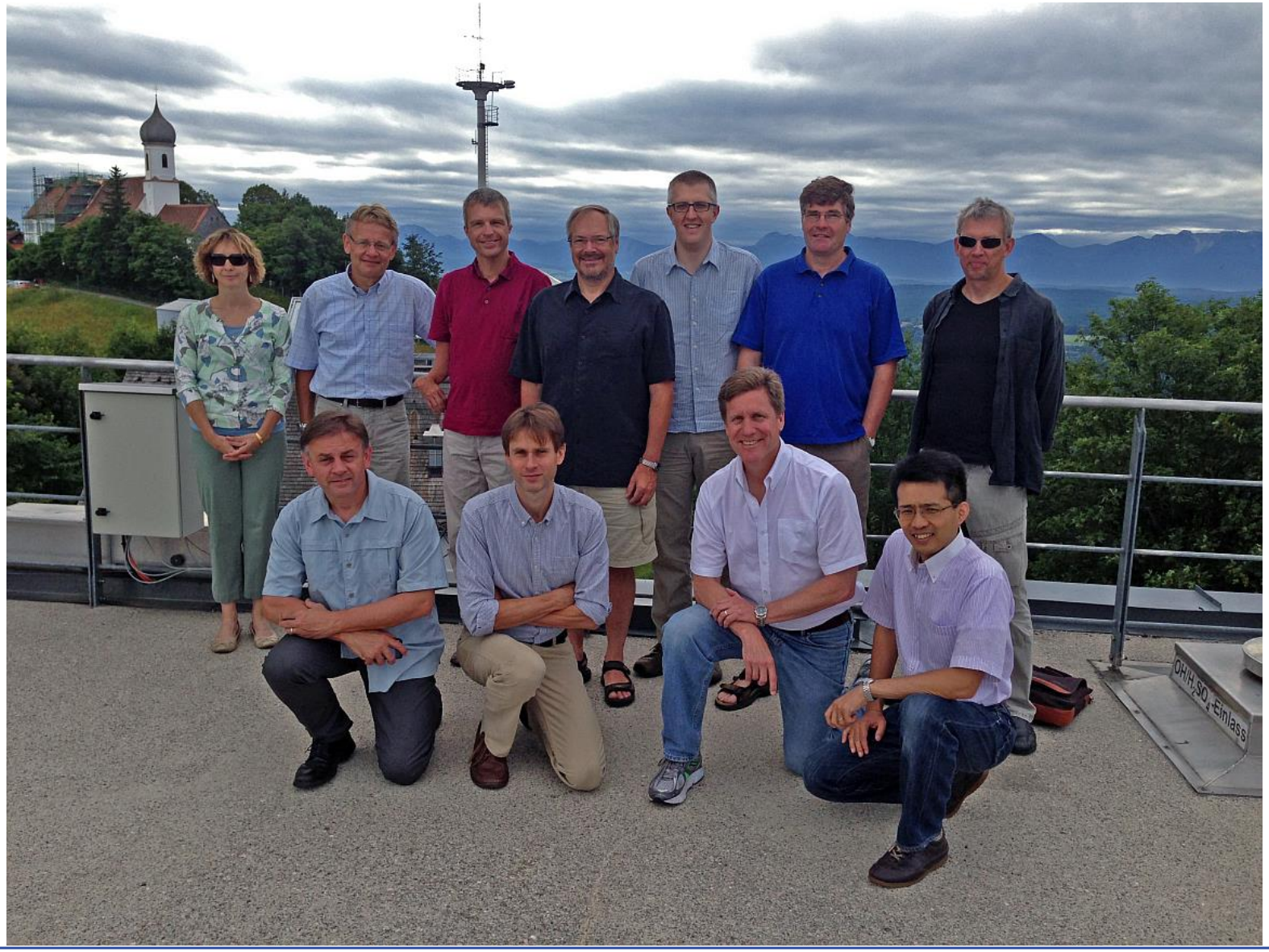
and many many colleagues!!

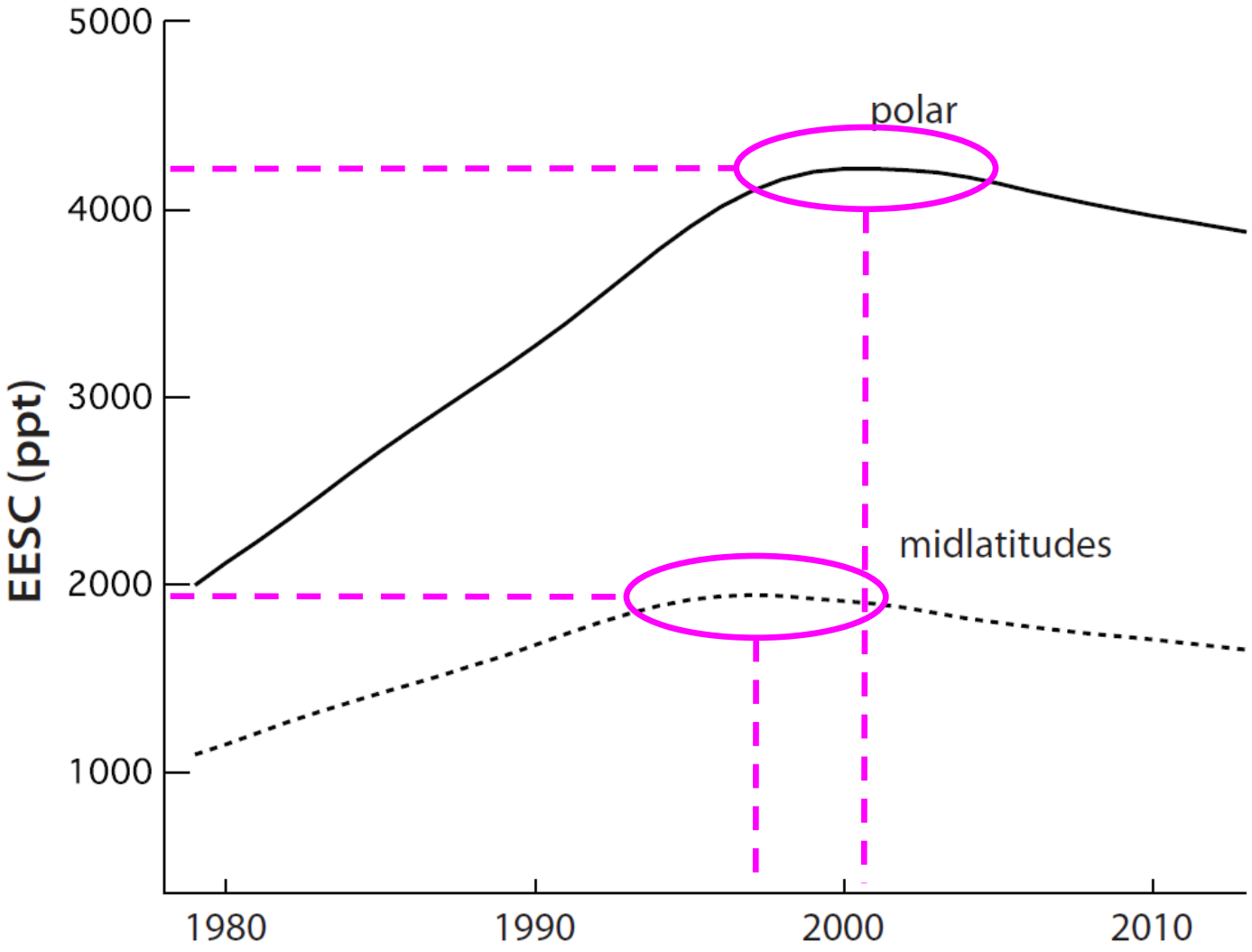
Chapter 2 meeting Hohenpeißenberg



outline

- Ozone depleting substances
- Global total column ozone
- Upper stratosphere
- Future ozone
- Summary & conclusions

Ozone Depleting Substances - EESC



EESC

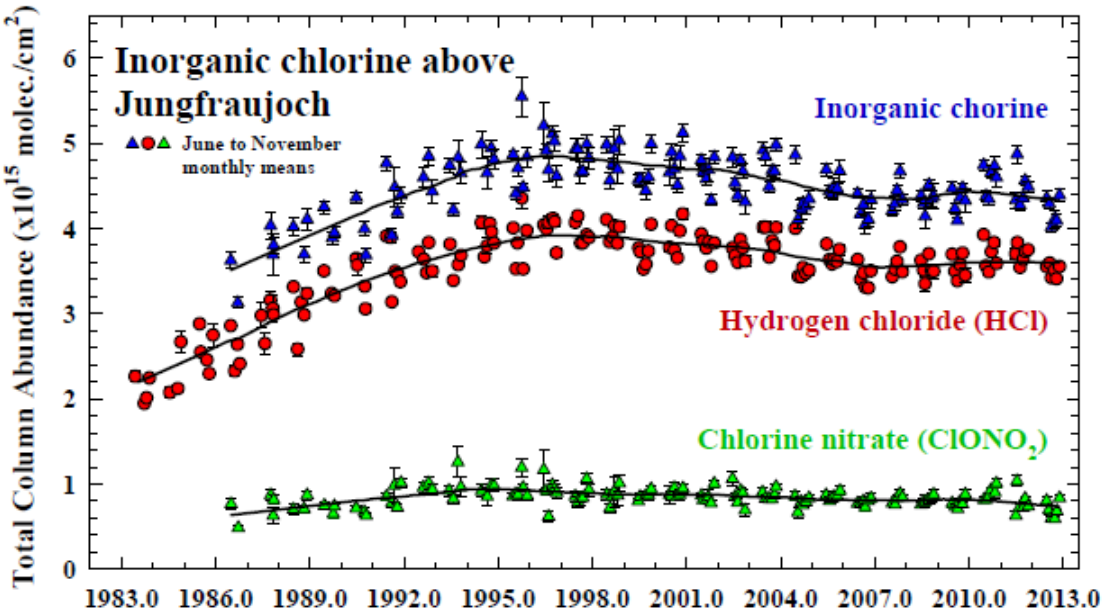
- peaks later at higher latitudes and higher altitudes
- more Cl and Br released at higher latitudes and higher altitudes
- hardly any chlorine in tropical lower stratosphere

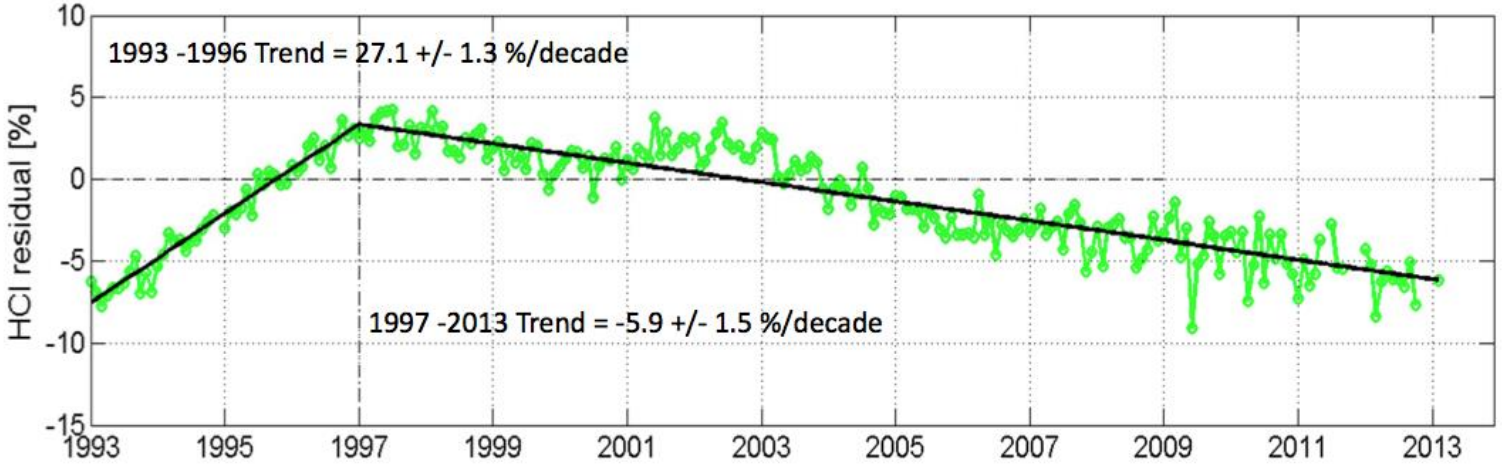
Newman et al., ACP, 2007

ODS – measured stratospheric chlorine

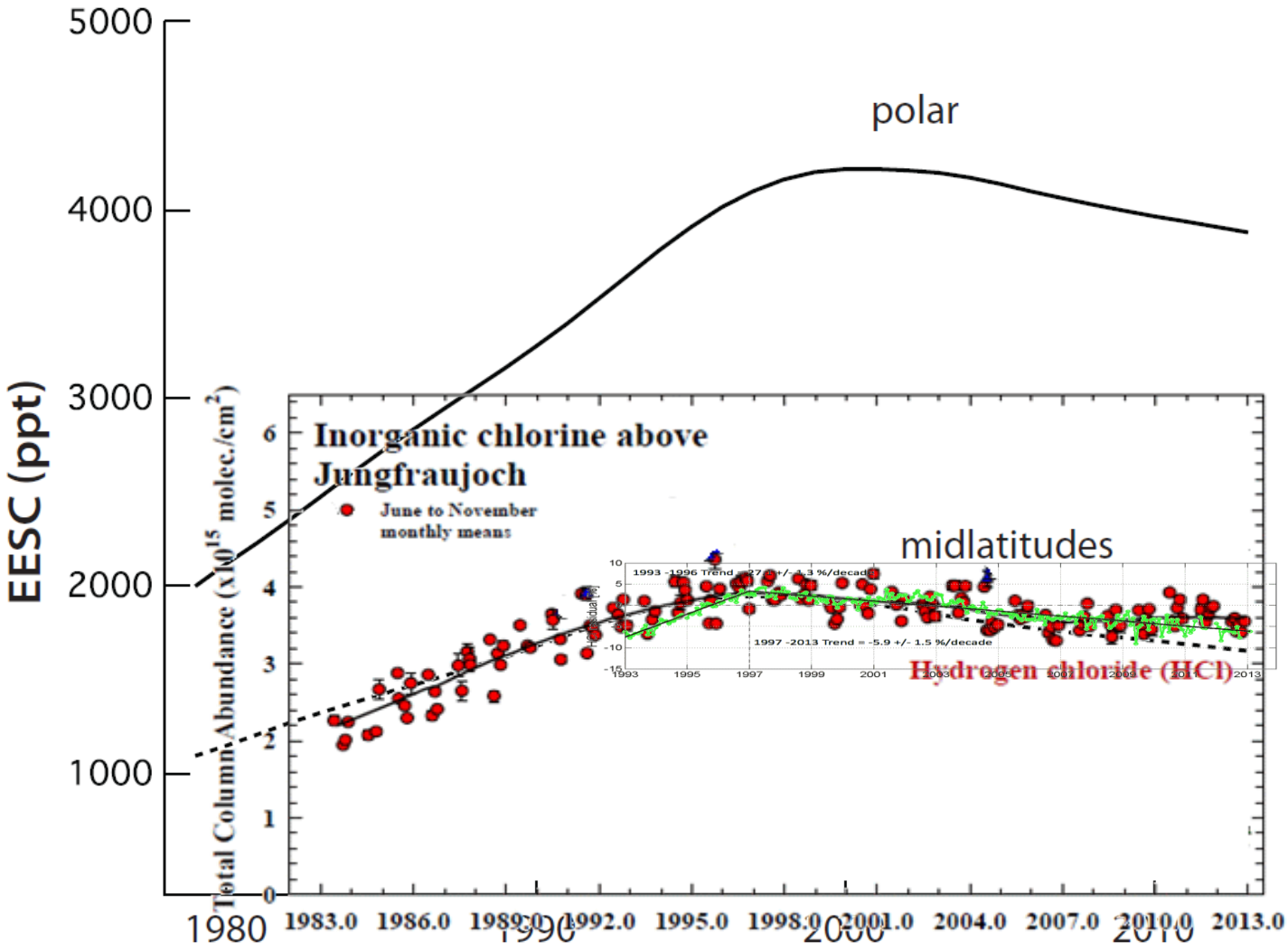
Total column @ Jungfraujoch
Jun-Nov, ground-based FTIR
Kohlhepp, … Demoulin, … Mahieu, … Zander, ACP, 2012

HCl, 35 to 45 km, 50°S to 50°N
satellites HALOE + ACE FTS
Jones et al., ACP, 2011

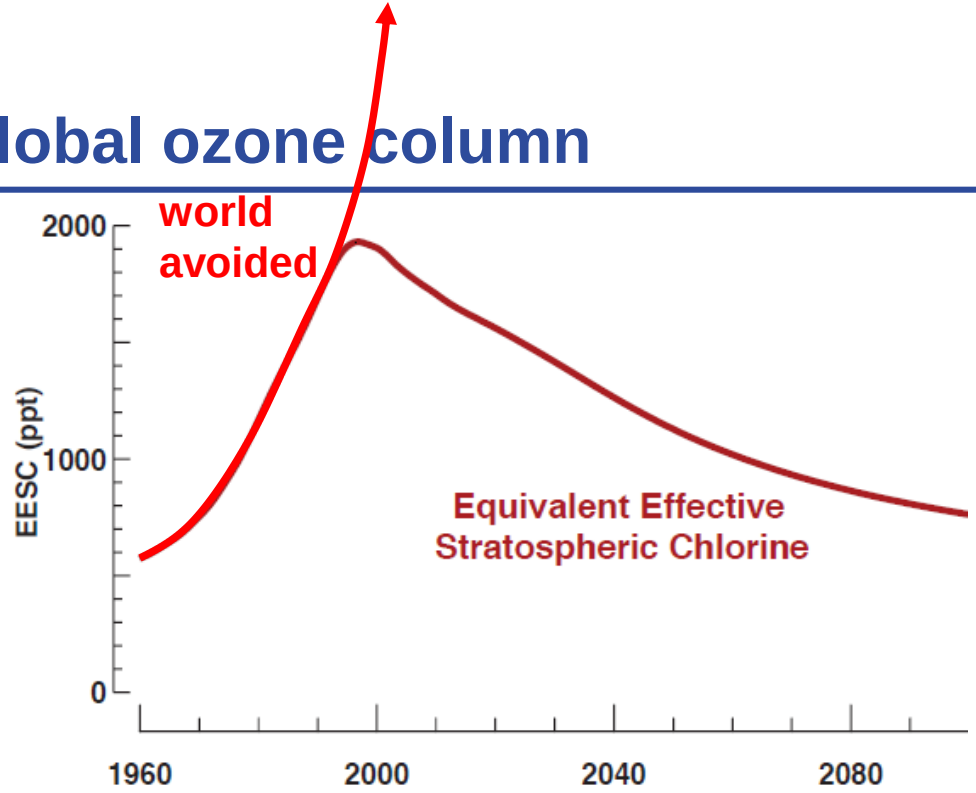


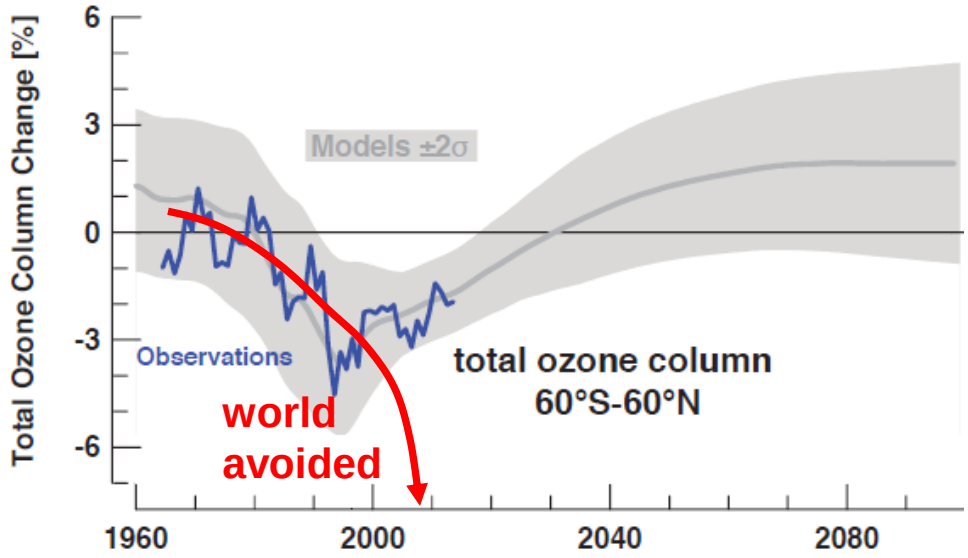


ODS – measured stratospheric chlorine



Global ozone column





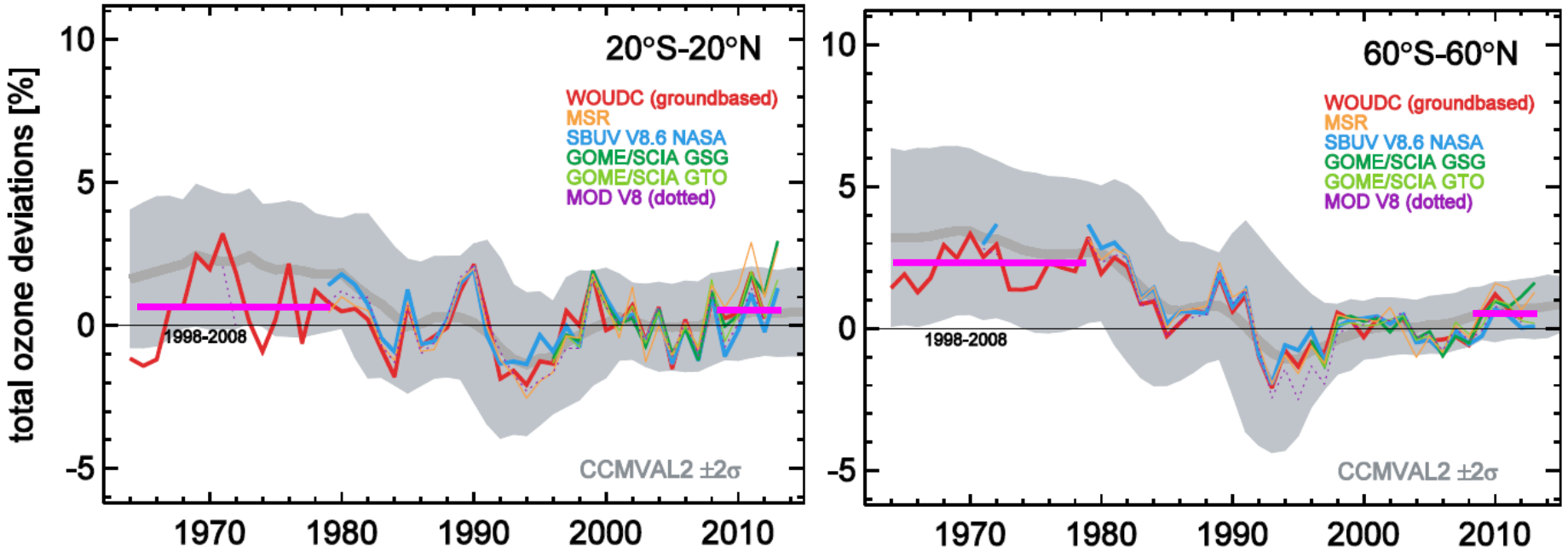
Observations:
ground-based (Dobson+Brewer)
satellite (SBUV, GOME-1,2, SCIAMACHY, …)

Chemistry Climate Models:
CCMVal-2, as in WMO 2010
Past+future ODS, CO_2, CH_4, N_2O, sea surface, (aerosol, solar, QBO)

Eyring et al., ACP, 2010

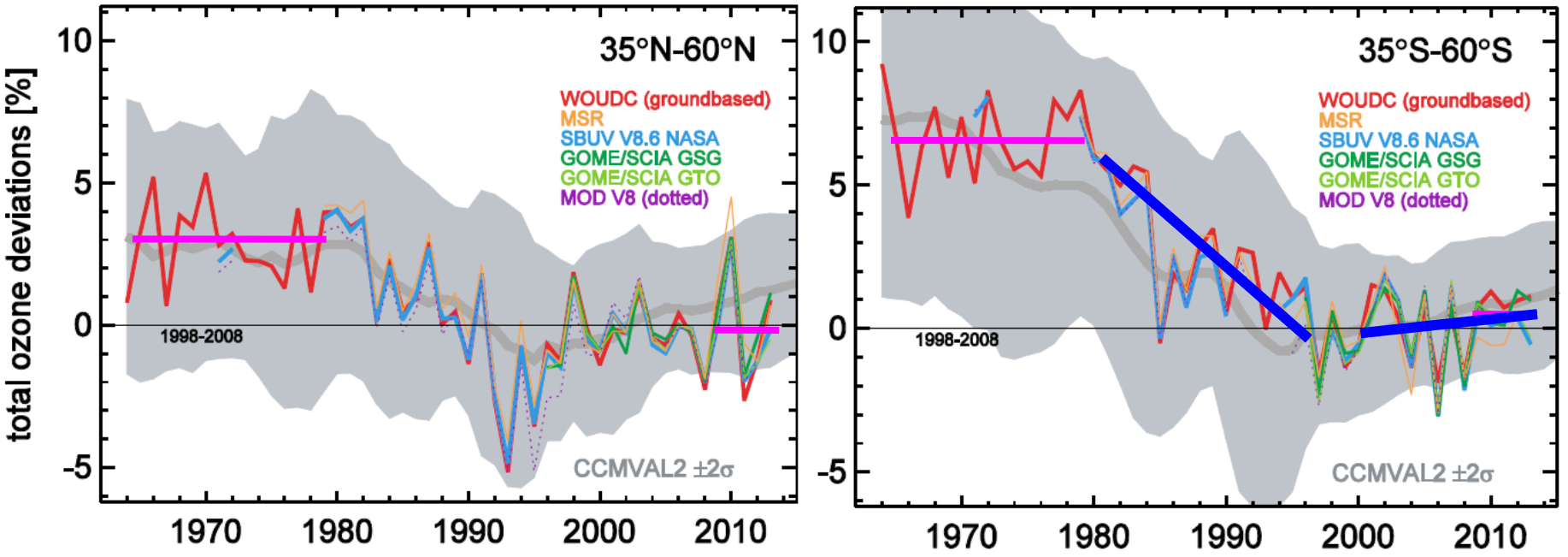
Observed changes in total column ozone

Compared to 1964-1980
≈ 0% Tropics (20S - 20N)
- 2% near global (60S – 60N)



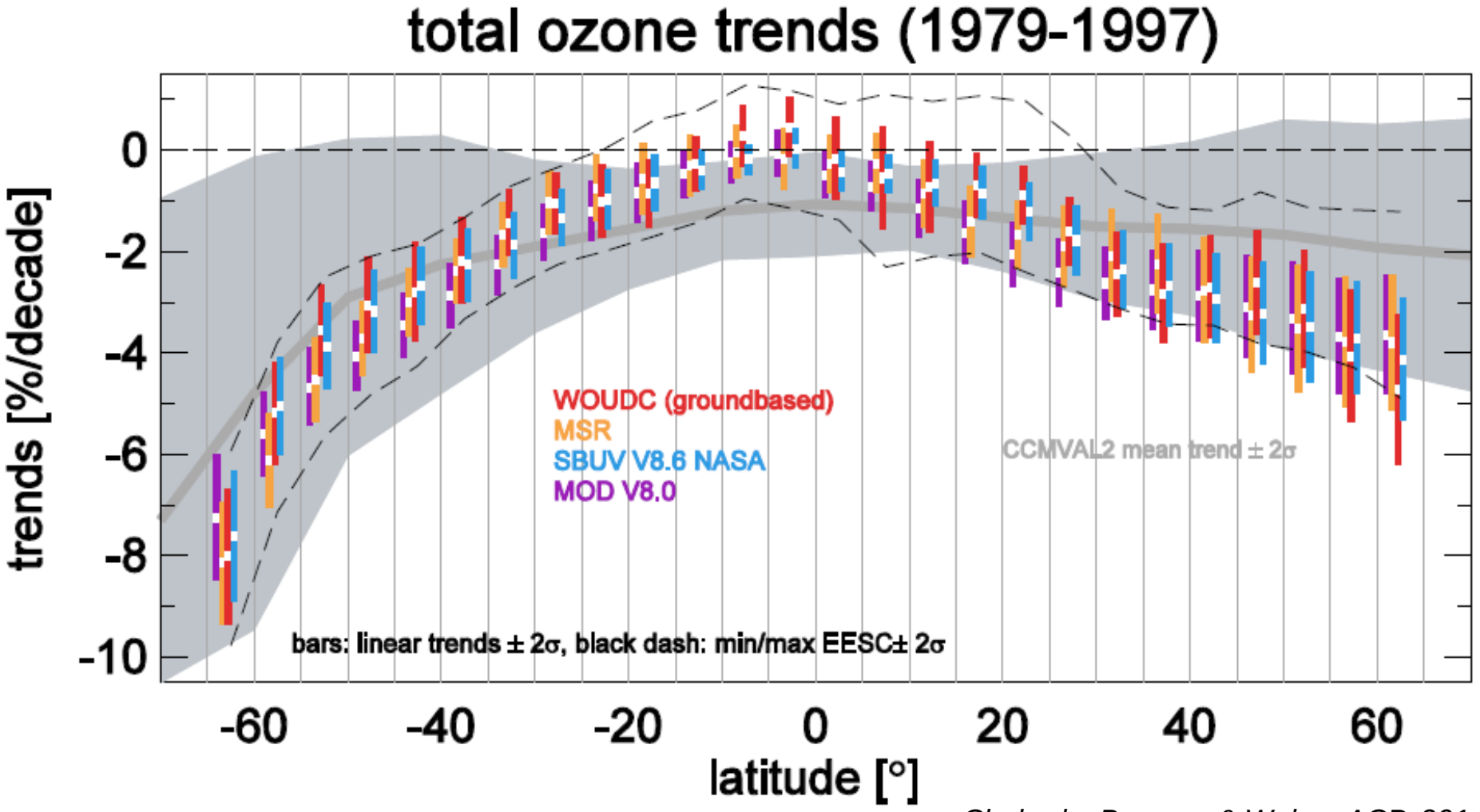
Observed changes in total column ozone

Compared to 1964-1980
- 3.5% Northern Hemisphere (35N - 60N)
- 6% Southern Hemisphere (35S - 60S)



Observed changes in total column ozone

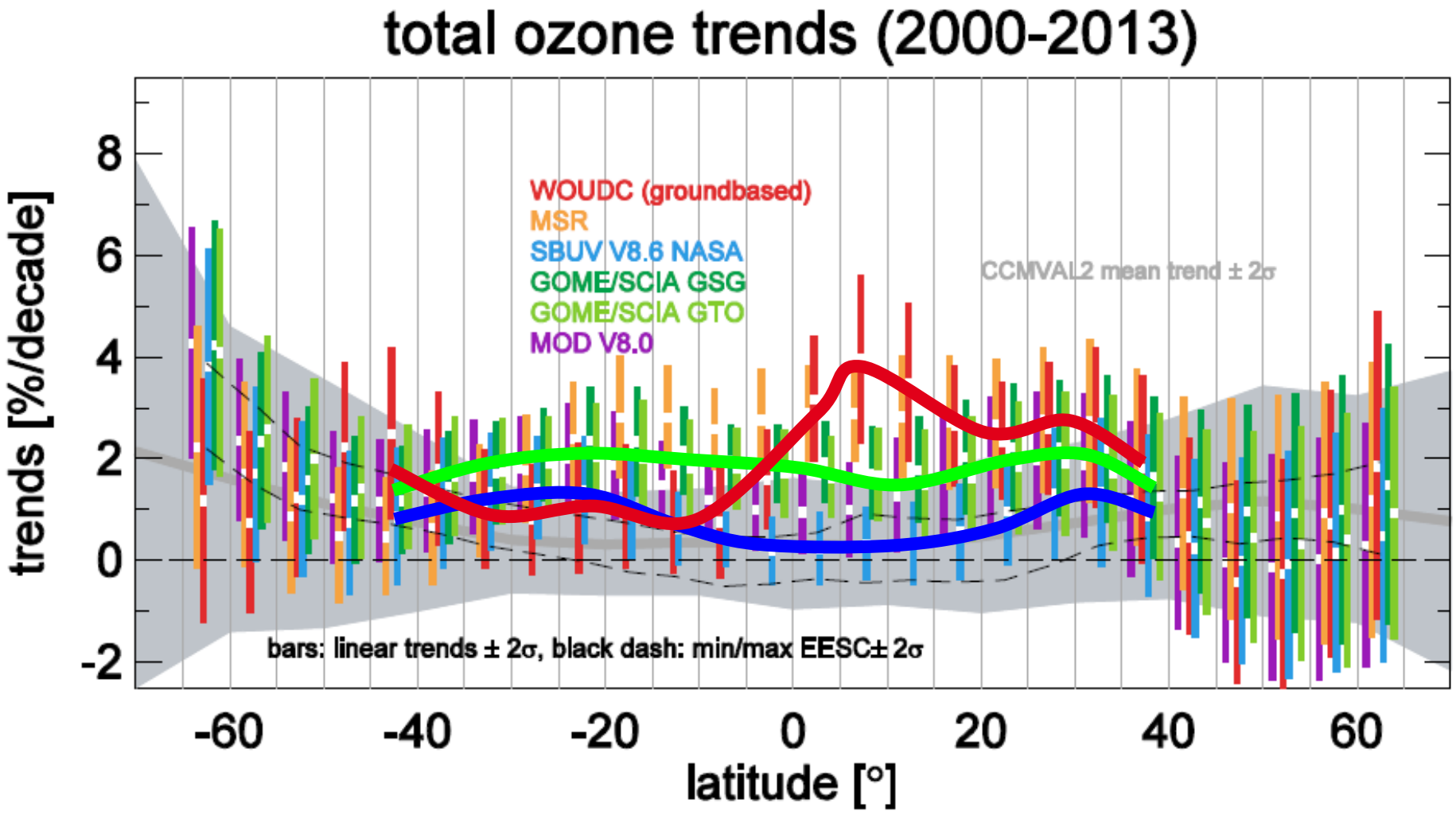
after accounting for QBO, solar cycle, ENSO, volcanos



Chehade, Burrows & Weber, ACP, 2014

Observed changes in total column ozone

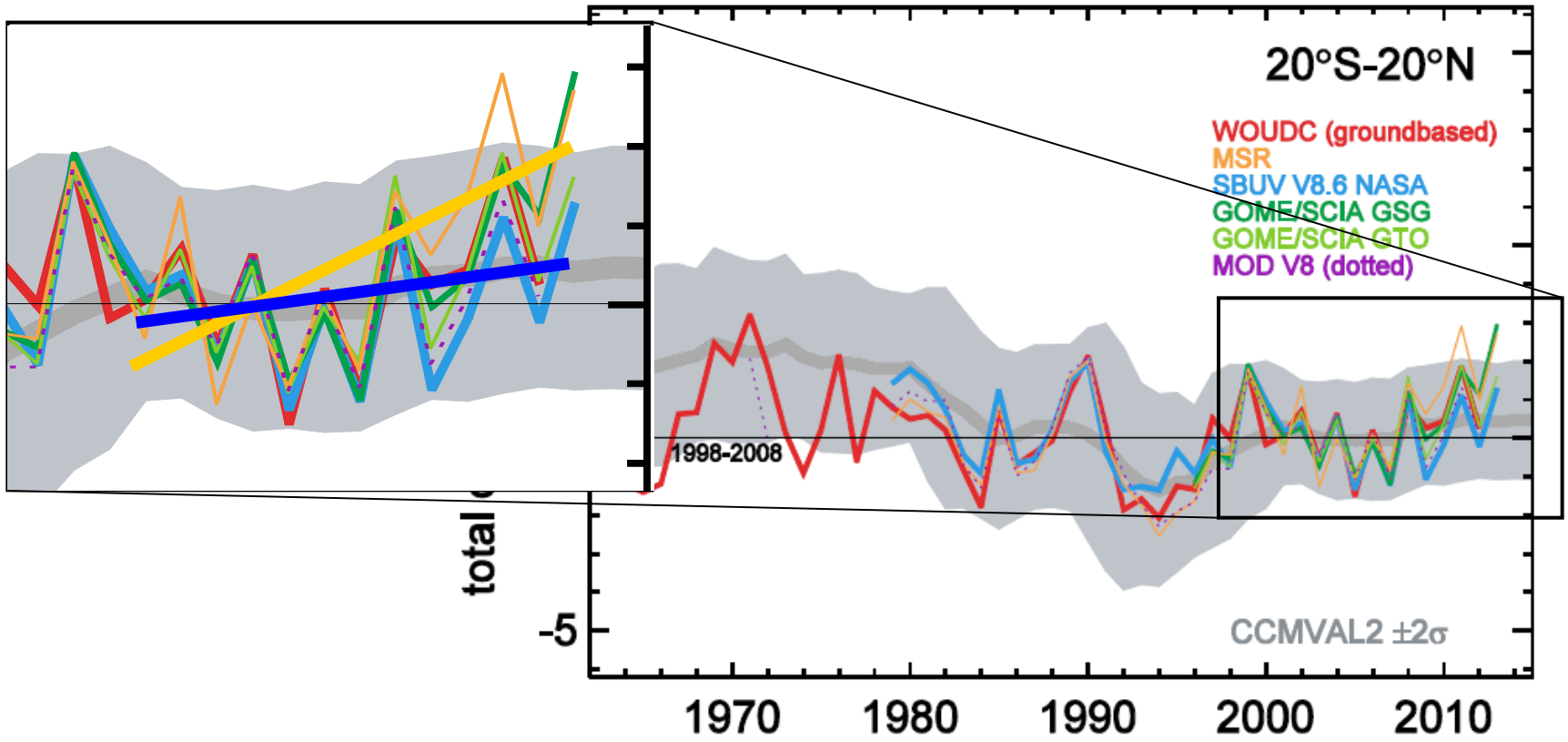
since ≈ 2000 ≈+1% per decade, some disagreement



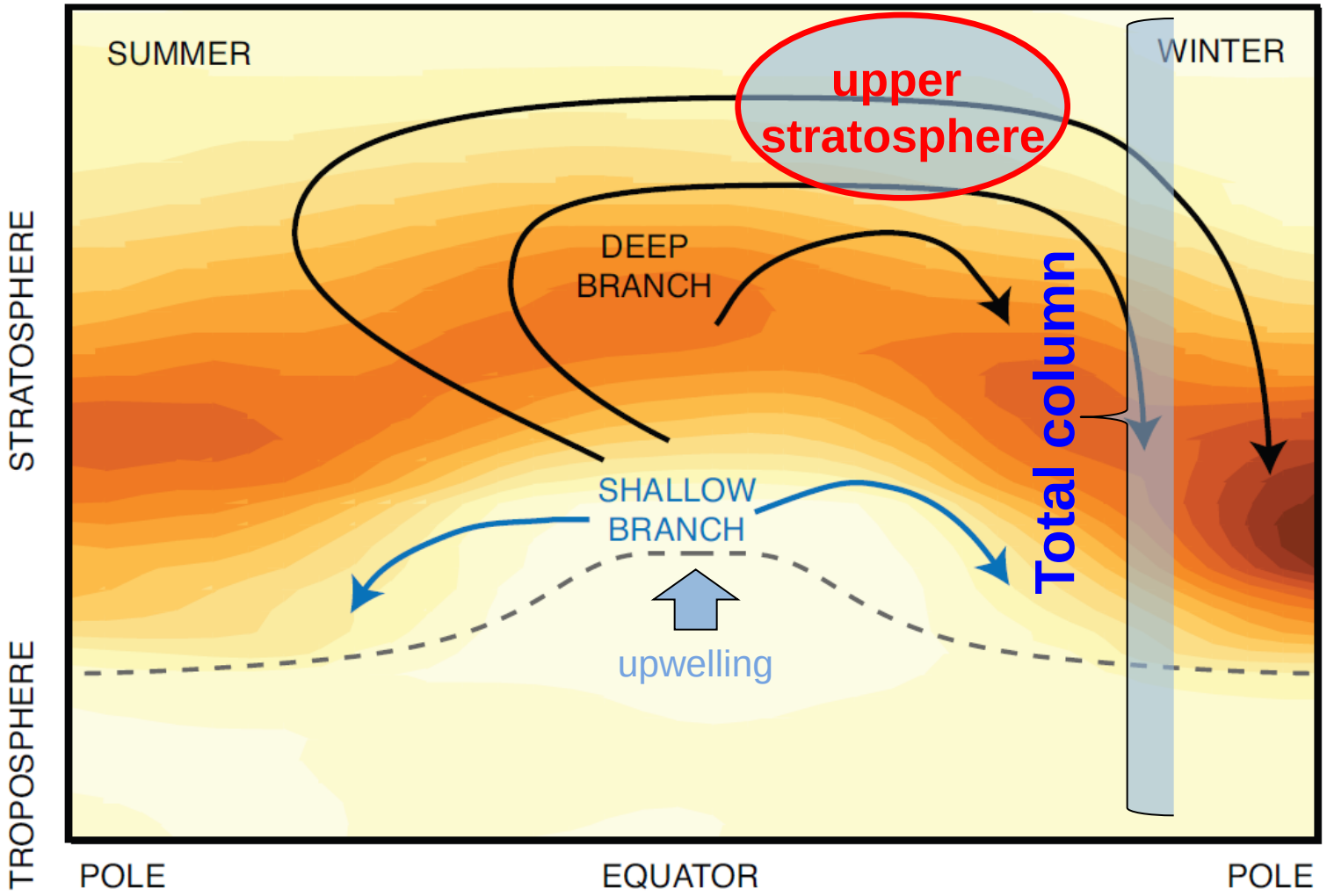
Chehade, Burrows & Weber, ACP, 2014

Observed changes in total column ozone

disagreement between datasets



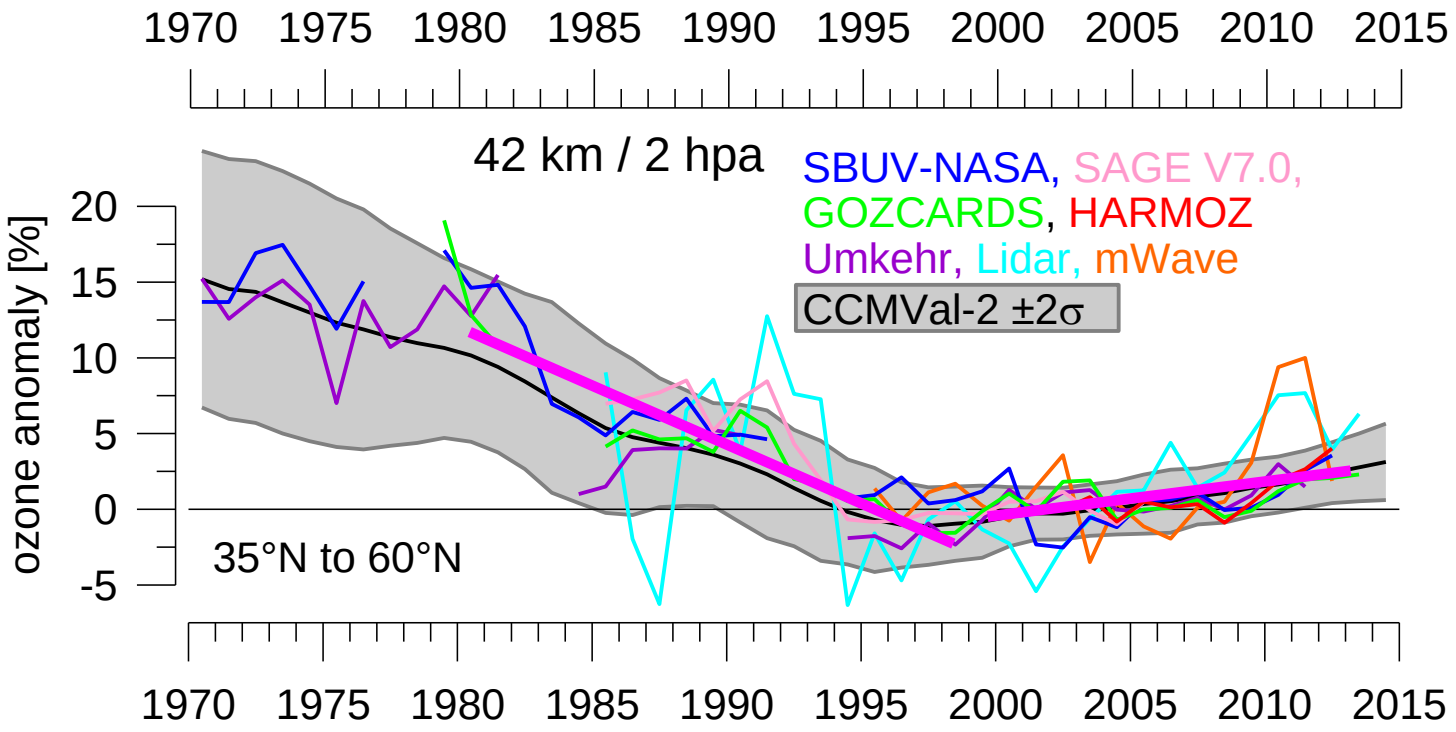
Brewer Dobson Circulation



Observed changes in ozone profiles

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

upper stratospheric ozone (35-45 km altitude)
+2.5 to 5% per decade



Observed changes in ozone profiles

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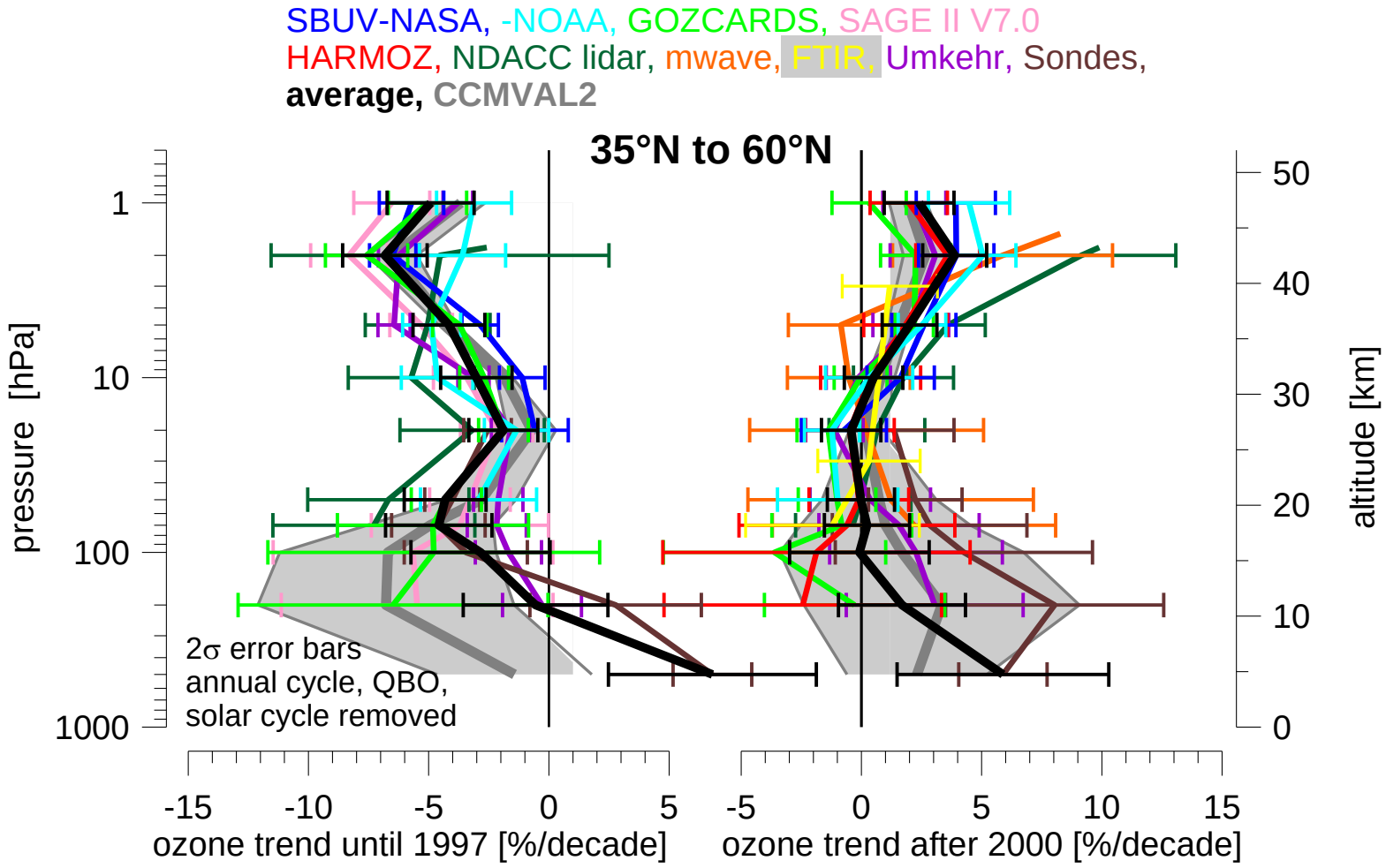
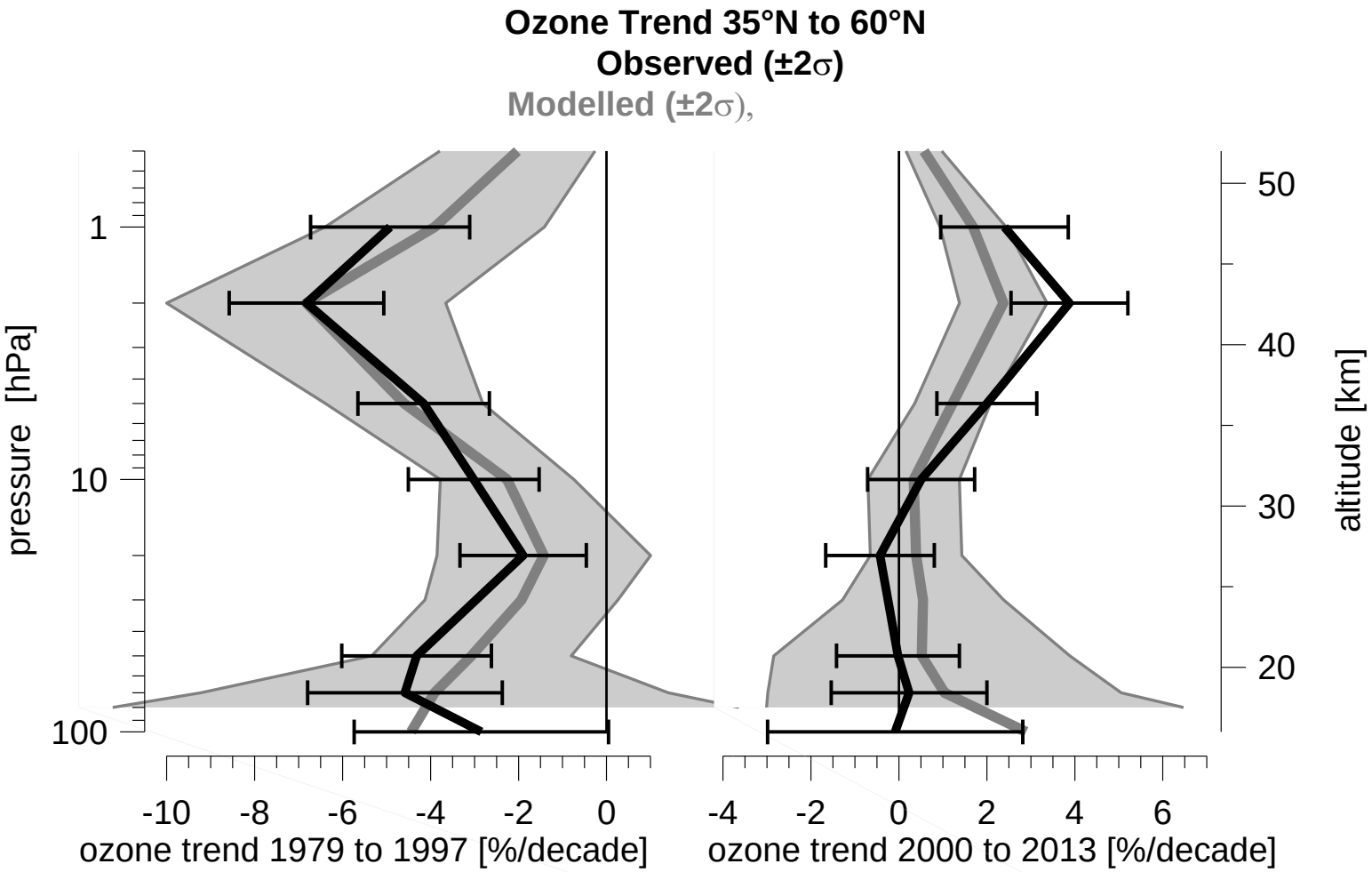
declining ozone before 1997

Some ozone increase after 2000



Observed changes in ozone profiles

observed & CCM simulated trends agree



Observed changes in ozone profiles

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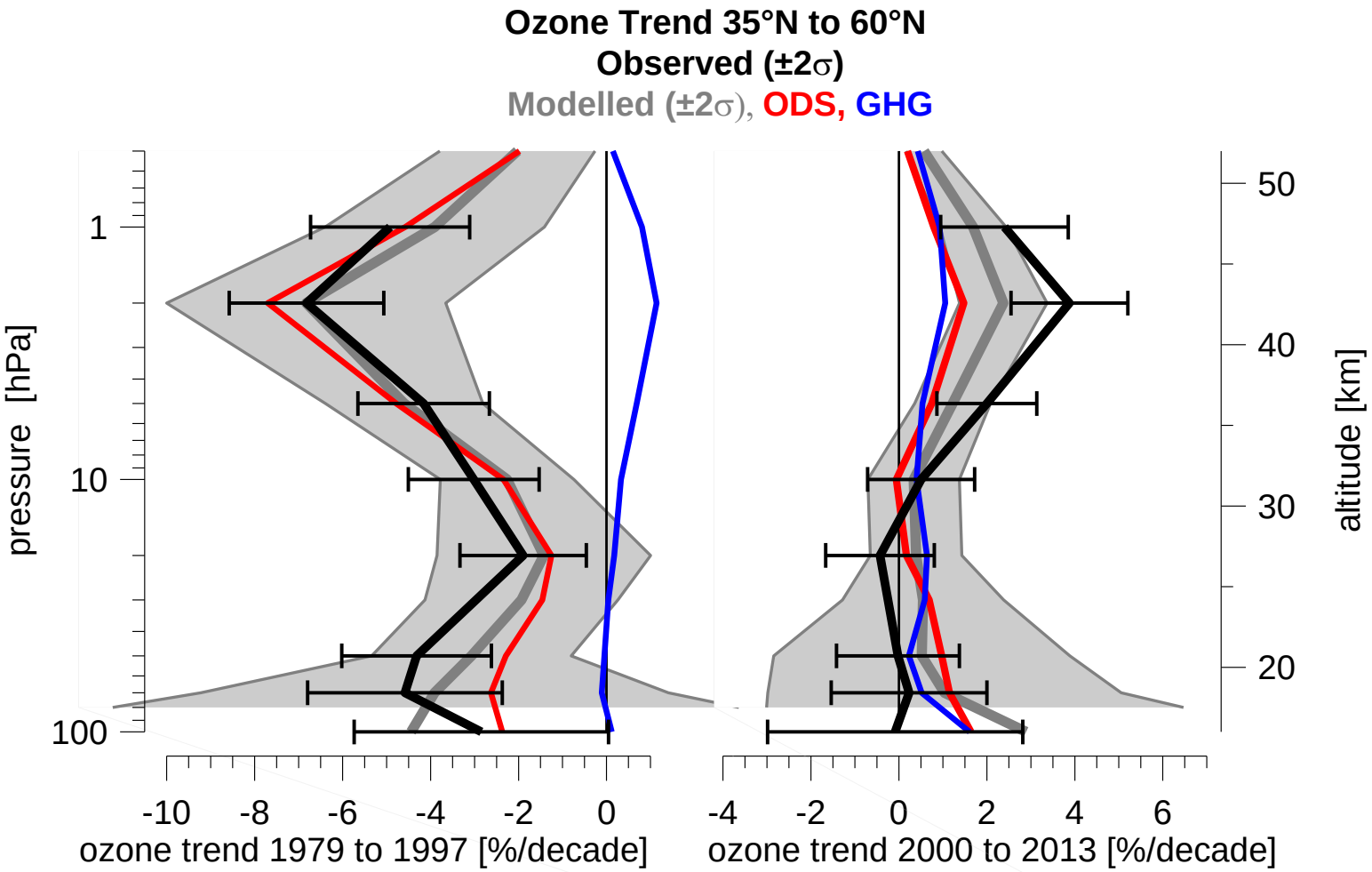
simulations: ½ ODS decline + ½ cooling by increasing CO_2



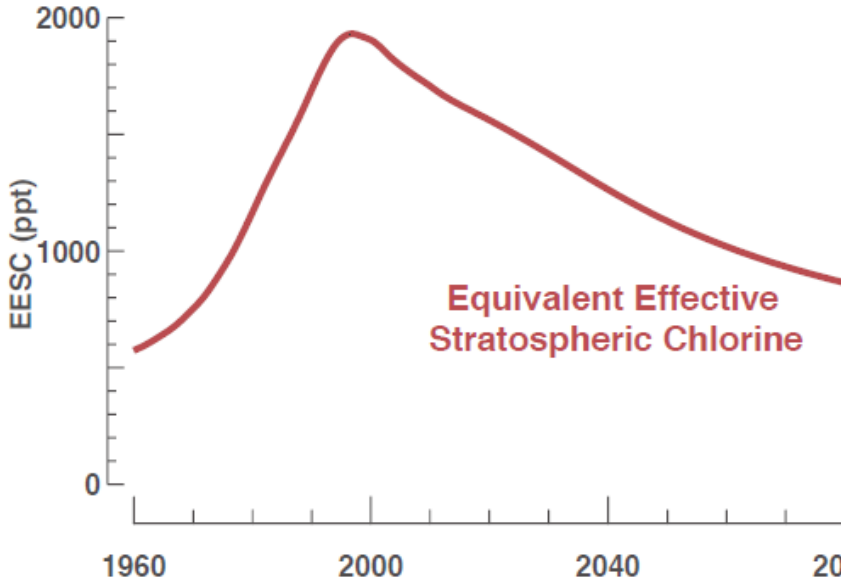
future ozone: drivers

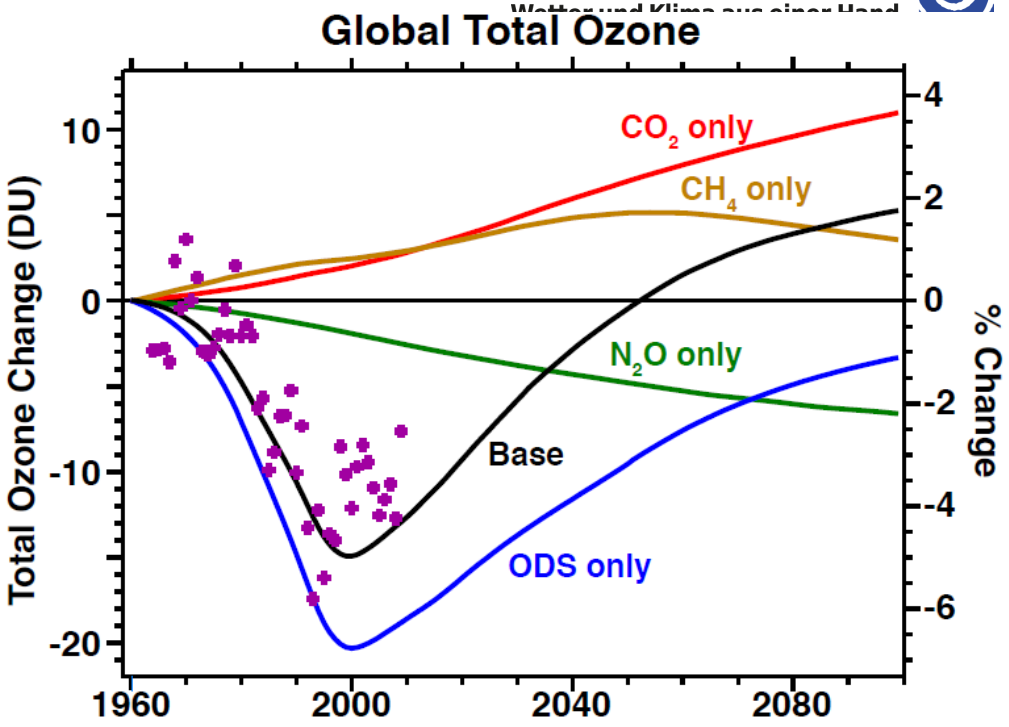
- decline of ozone depleting substances (ODS)
- increase of CO_2 & stratospheric cooling
- climate change and changing Brewer-Dobson-Circulation

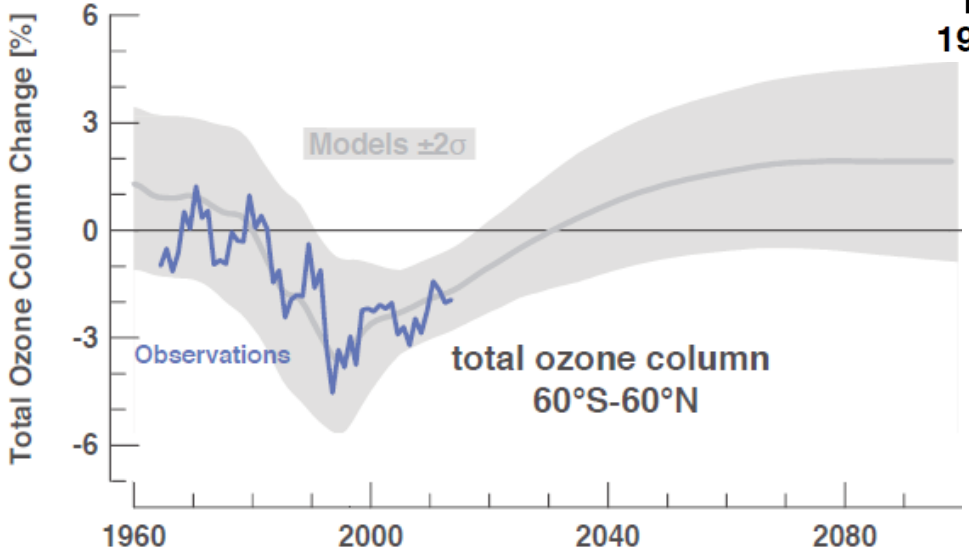
- N_2O changes
- CH_4 changes

- volcanoes & geoengineering

future ozone: drivers







➔ **ODS deplete O3**

➔ **CO_2 cools**

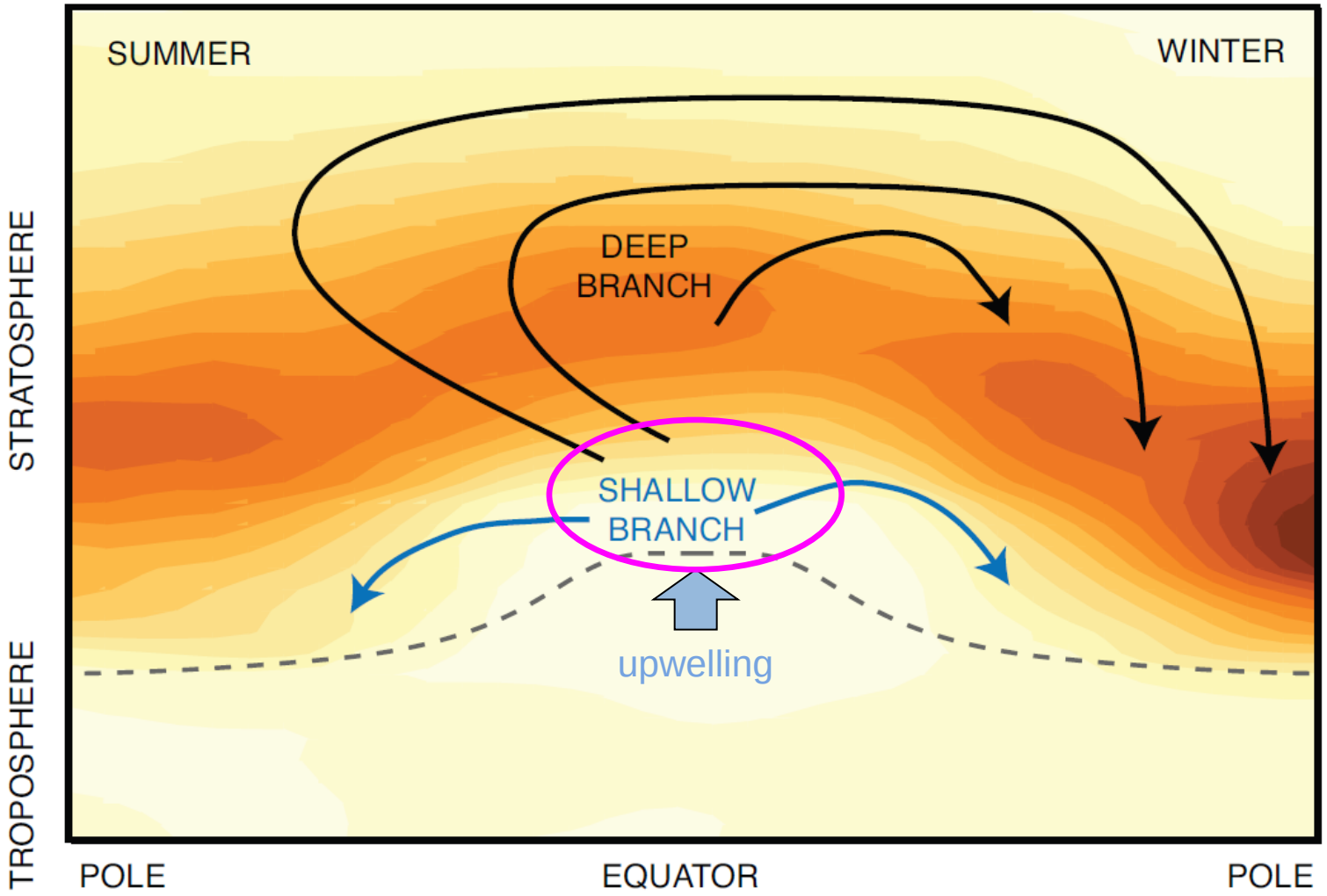
➔ **N_2O depletes O_3**

➔ **CH_4 increases O_3**

Fleming ACP 2011, Portmann RoySoc 2012

Brewer Dobson Circulation

Models simulate increasing BDC on 50 to 100 year time-scale



Tropical ozone – no ODS, but climate

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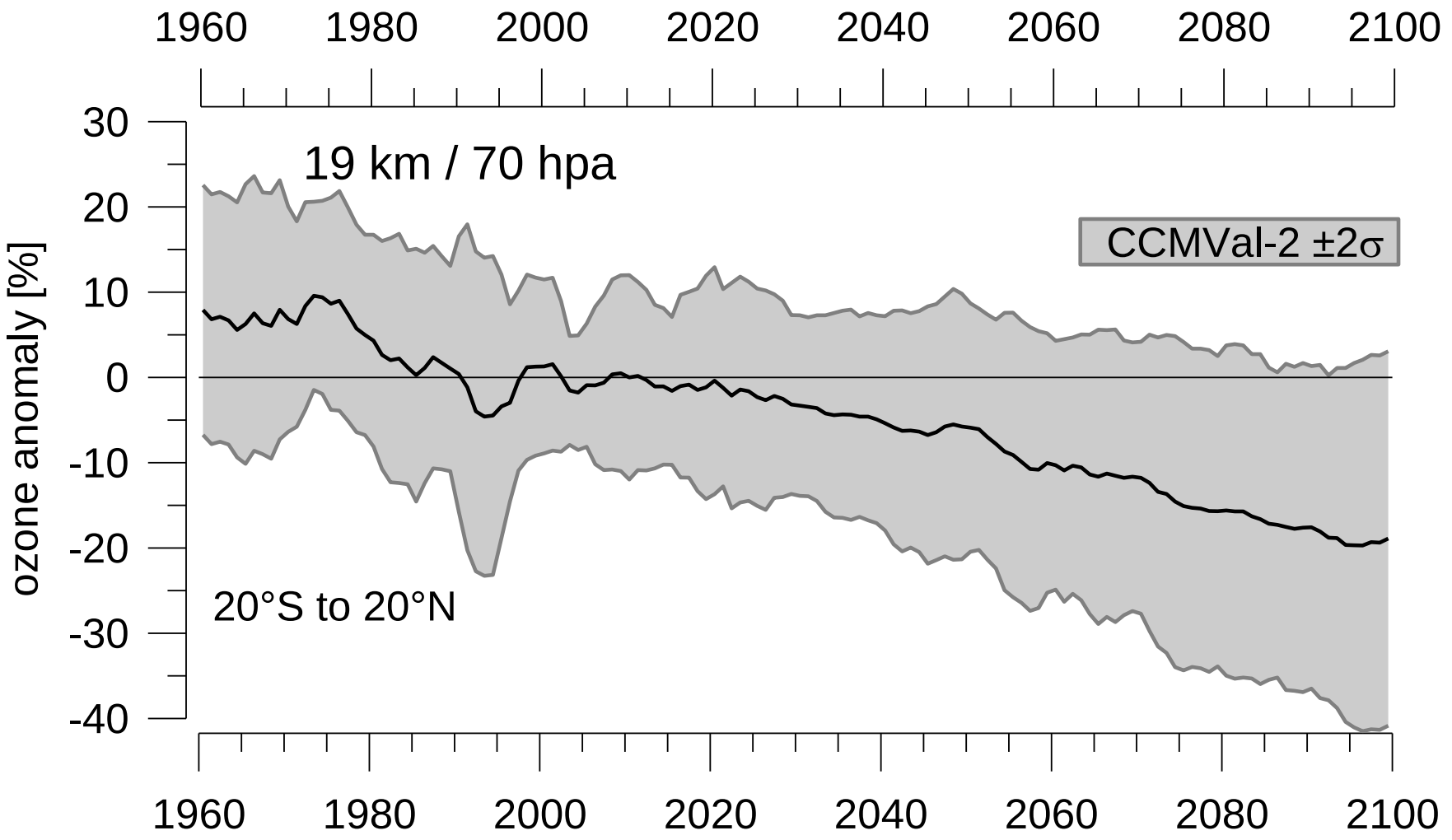
Models simulate increasing BDC – declining ozone in tropical LS



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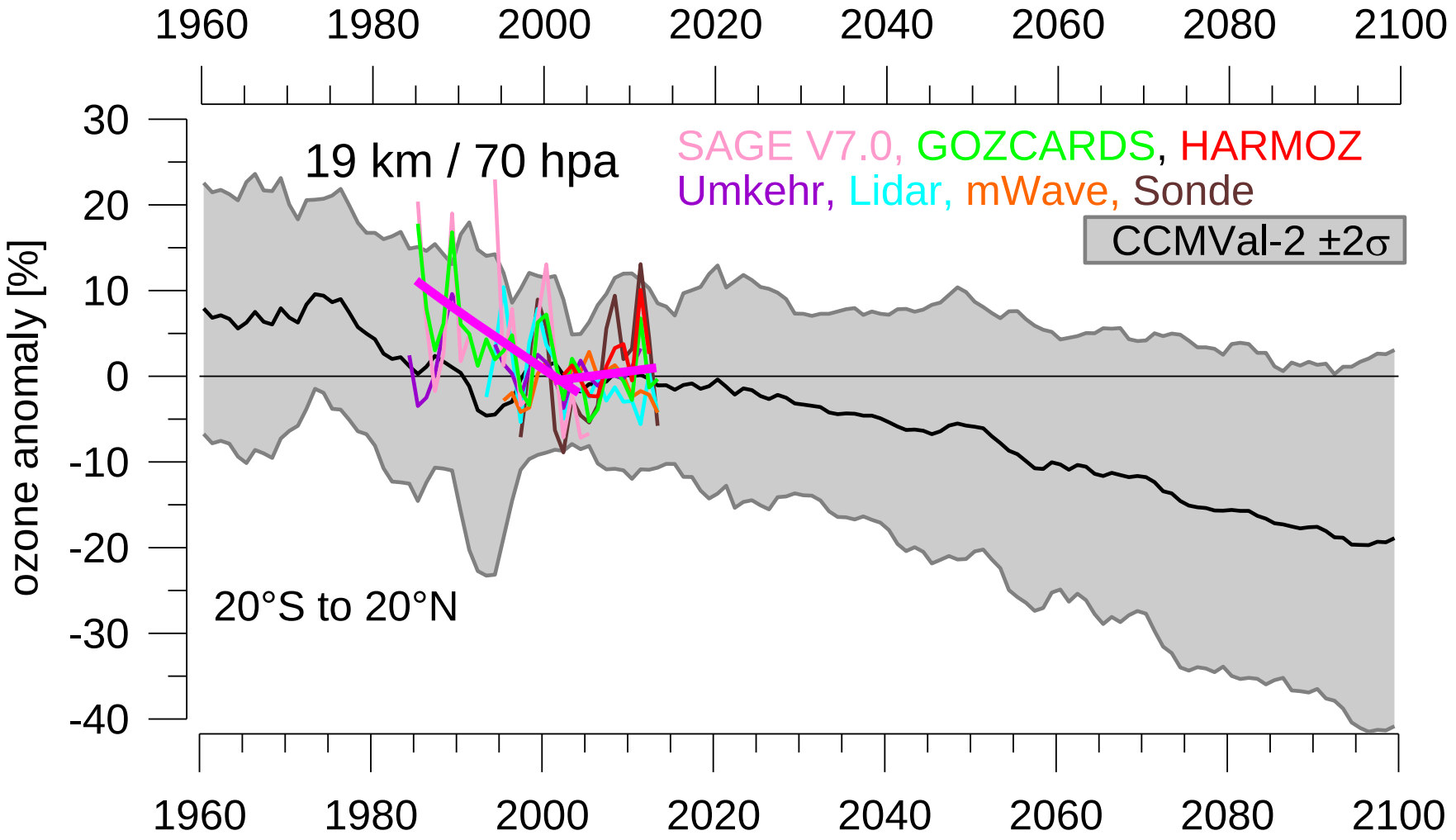
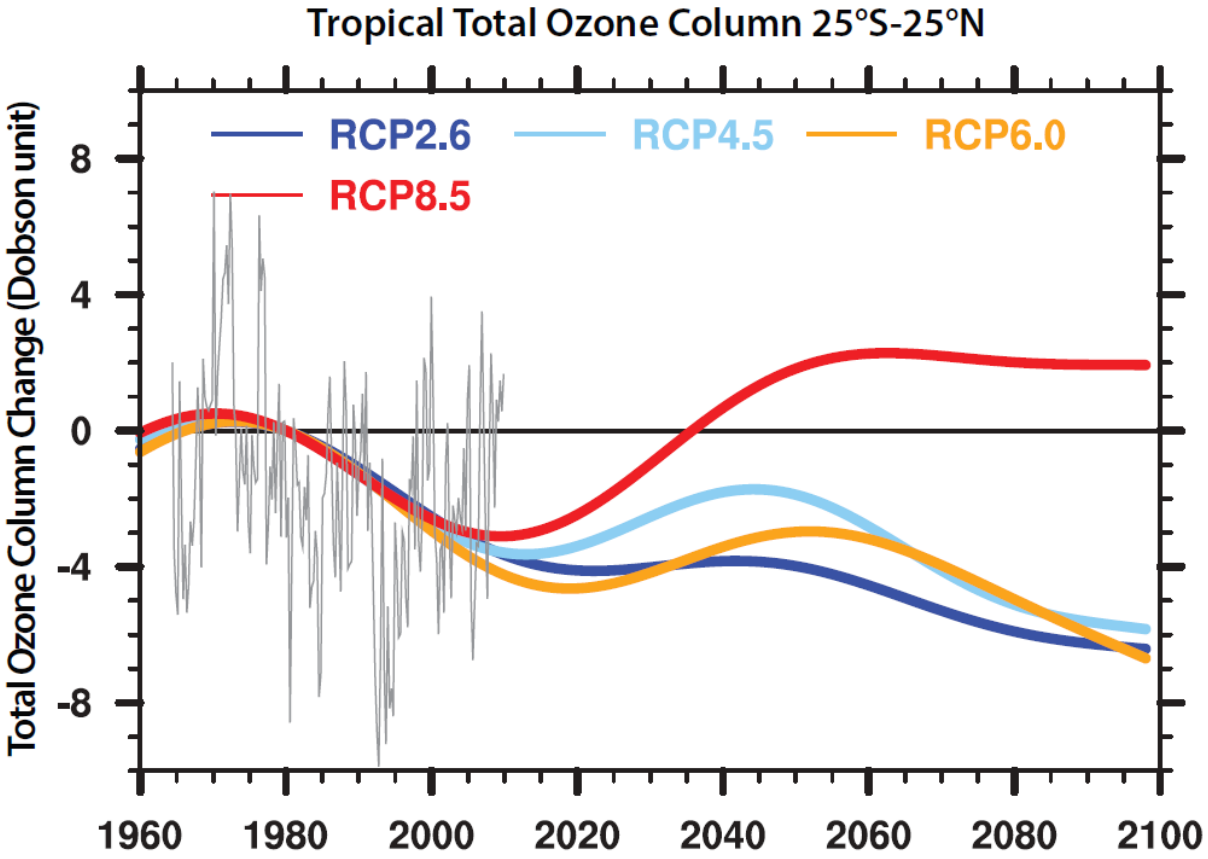


Tropical ozone – a key region

- Sensitive to climate / BDC changes
- Stratospheric decline?
- Tropospheric increase?
- Observations?



Eyring et al., JGR, 2013

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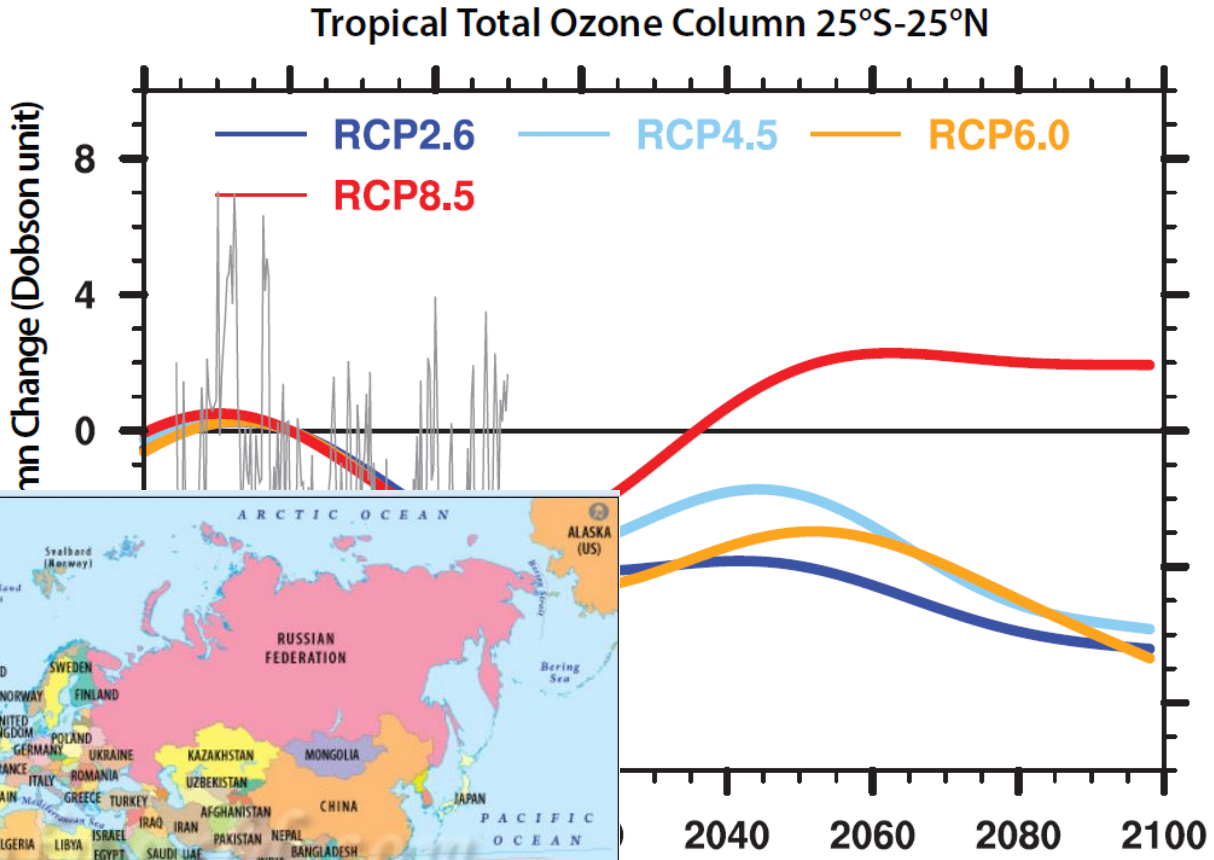

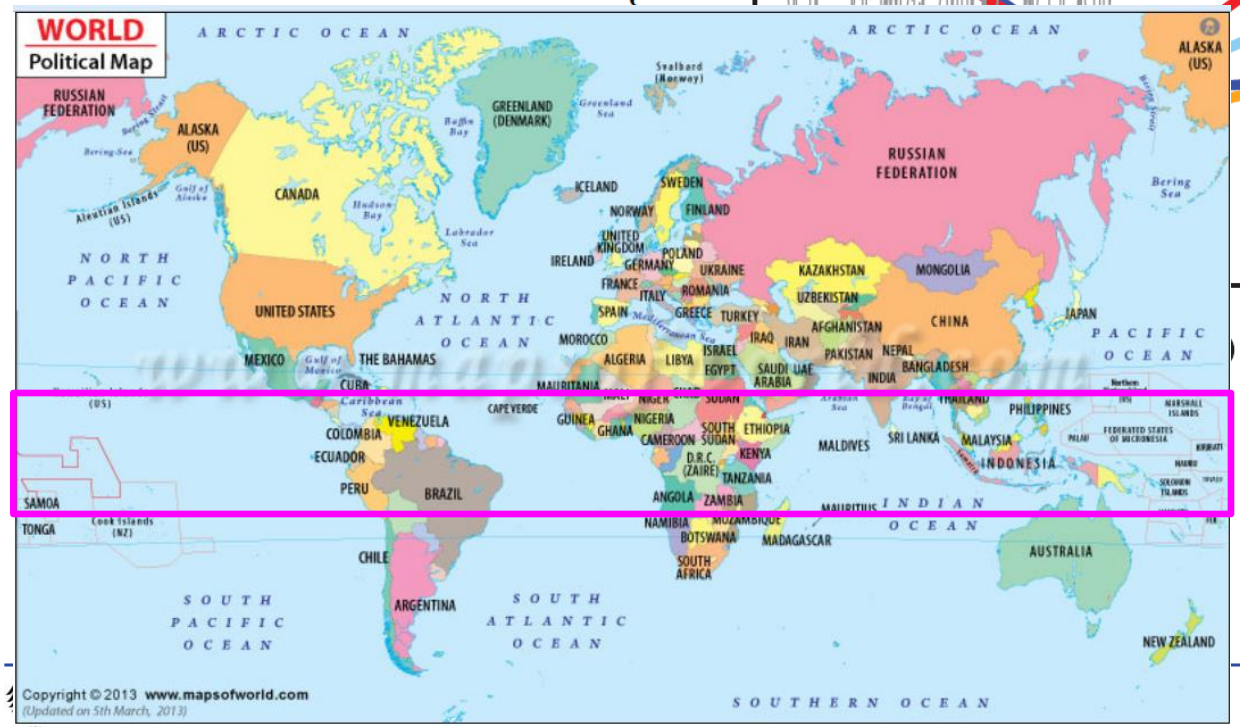

Eyring et al., JGR, 2013

summary

- Montreal protocol was successful !!
- ODS are going down (-10% to -15% from peak around 2000)
- ozone is starting to recover
- CO_2, other emissions (N_2O, CH_4) & climate change drive future
- ozone recovery by 2030/40, Antarctic after 2050 (later to 1960s levels)

- volcanoes & geoengineering will reduce O_3 (while ODS/ chlorine high)

- accurate observations remain necessary !
- modelling remains necessary for understanding & predicting !
- „The mission goes on“ (UNEP/WMO 10.Sep.2014)

Not covered:

climate benefits, SH climate change, future HFC radiative forcing