# The current and future states of the ozone layer

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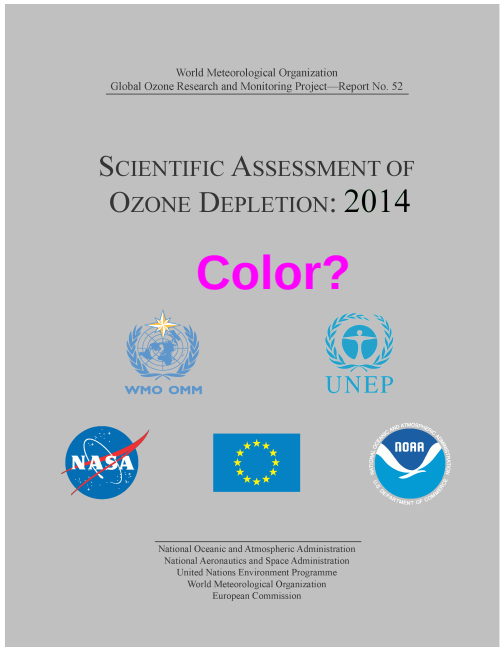
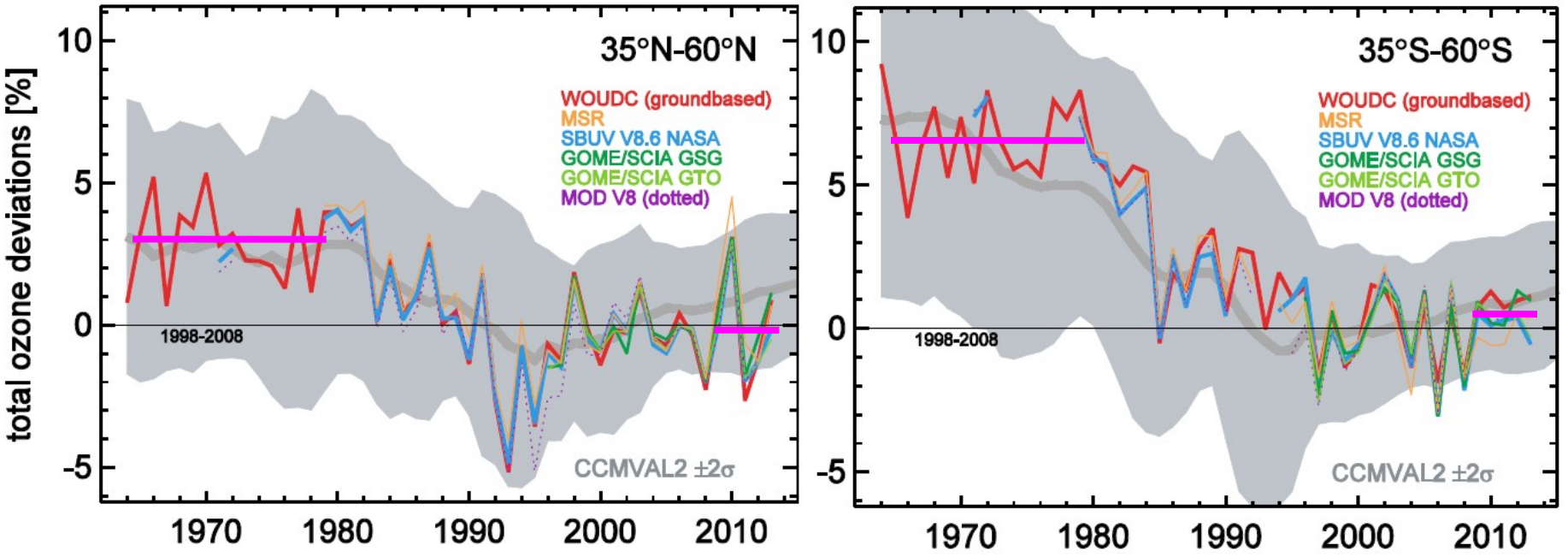
**and all the colleagues working on the 2014 Ozone Assessment**



# Observed changes in total column ozone

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

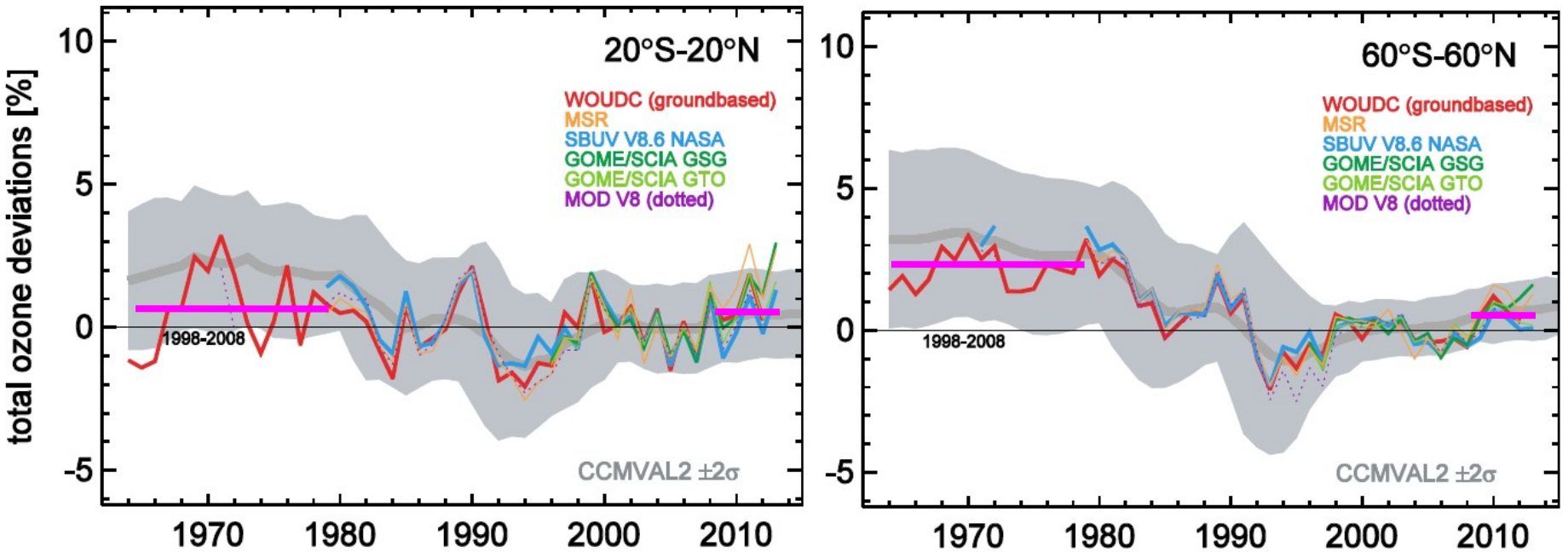


# Observed changes in total column ozone

**Compared to 1964-1980**

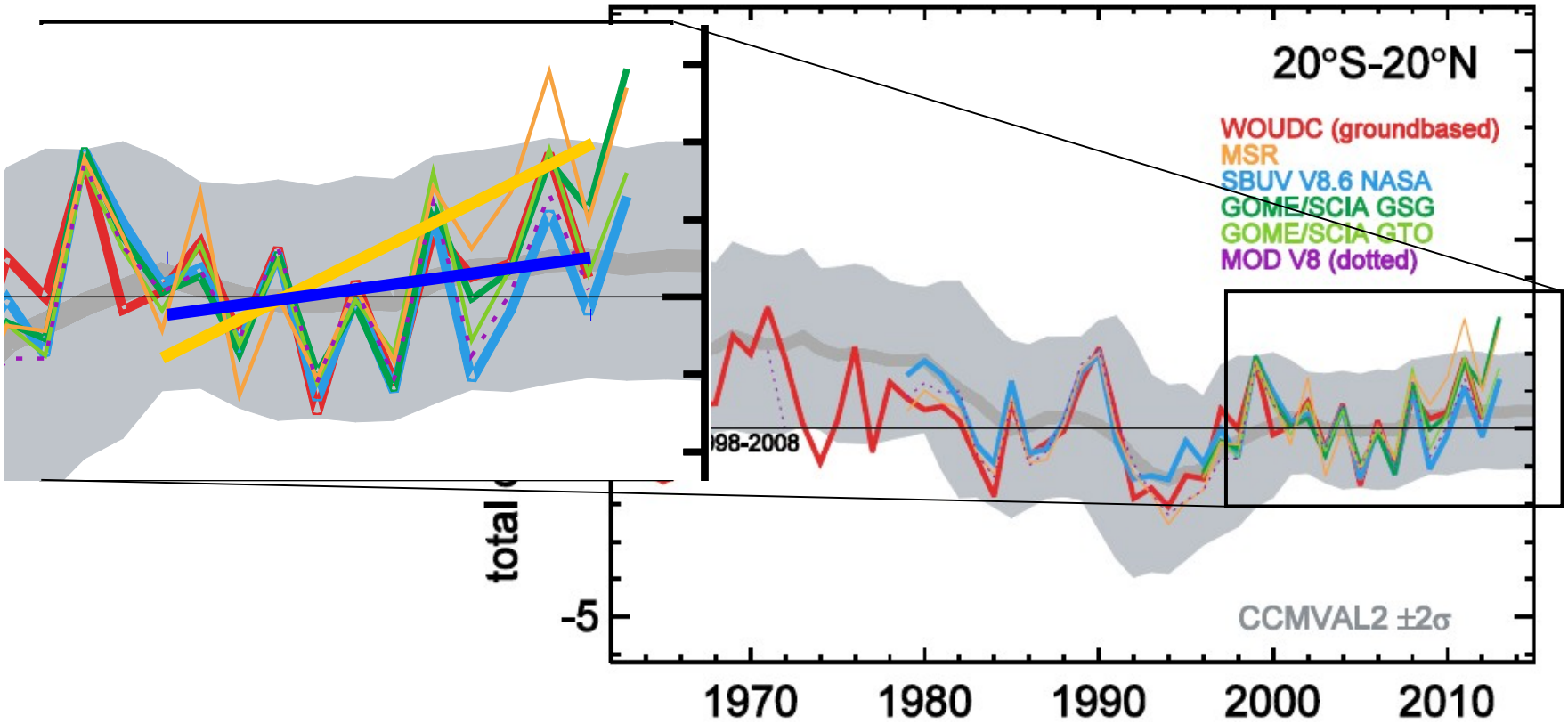
**≈ 0% Tropics** (20S - 20N)

**- 2% near global** (60S – 60N)



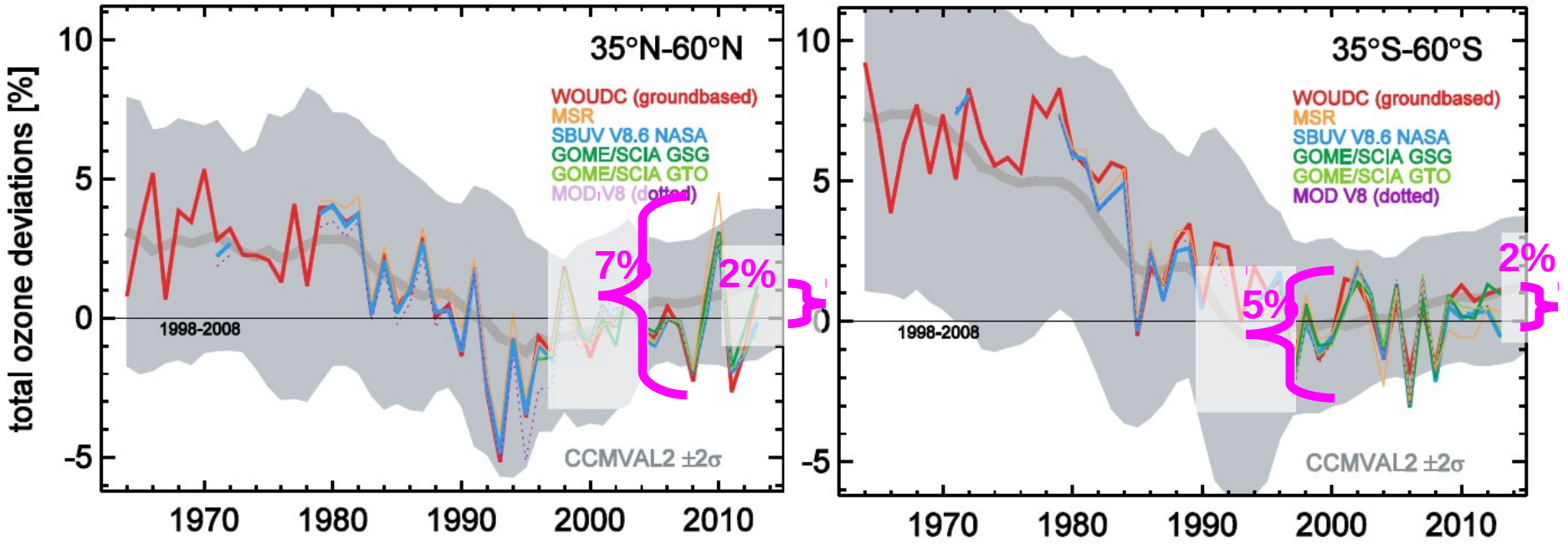
# Observed changes in total column ozone

## disagreement between datasets

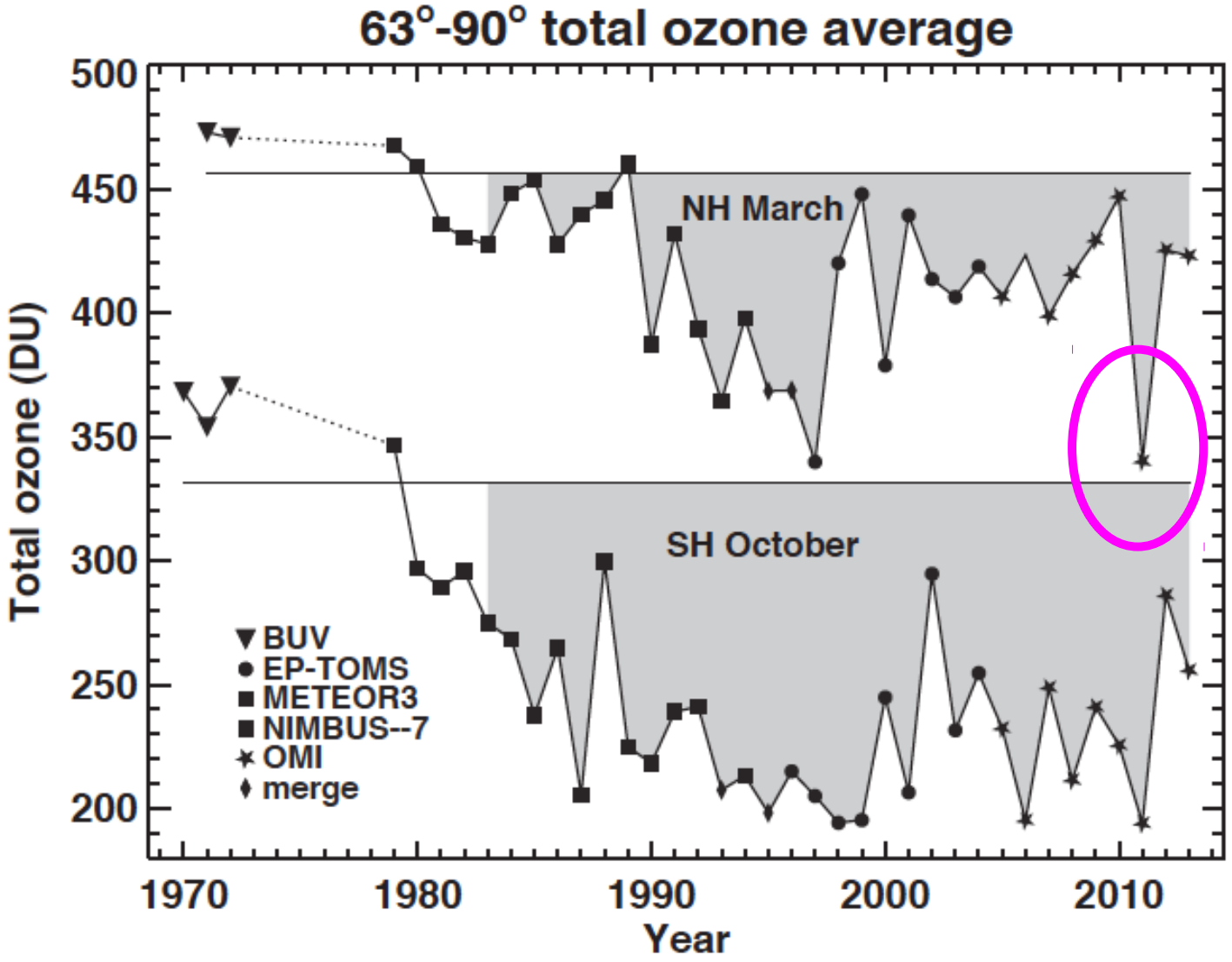


# Observed changes in total column ozone

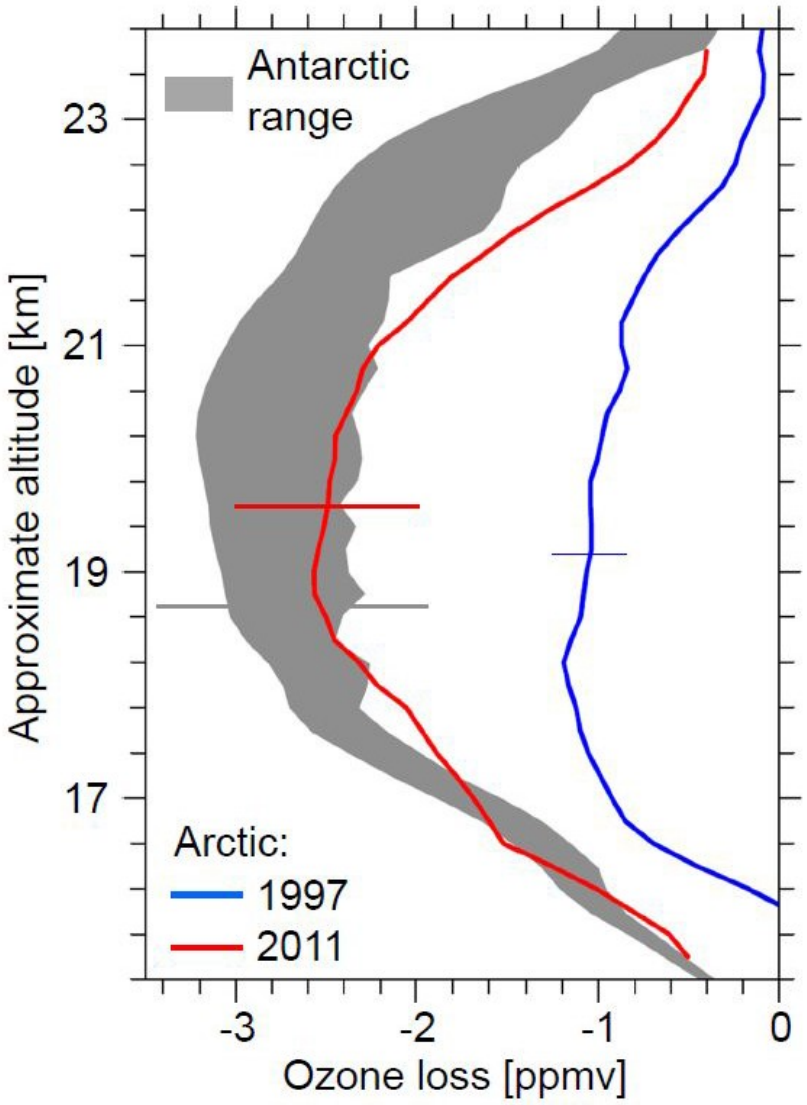
**separation ODS-related increase ↔ natural variability not made yet**

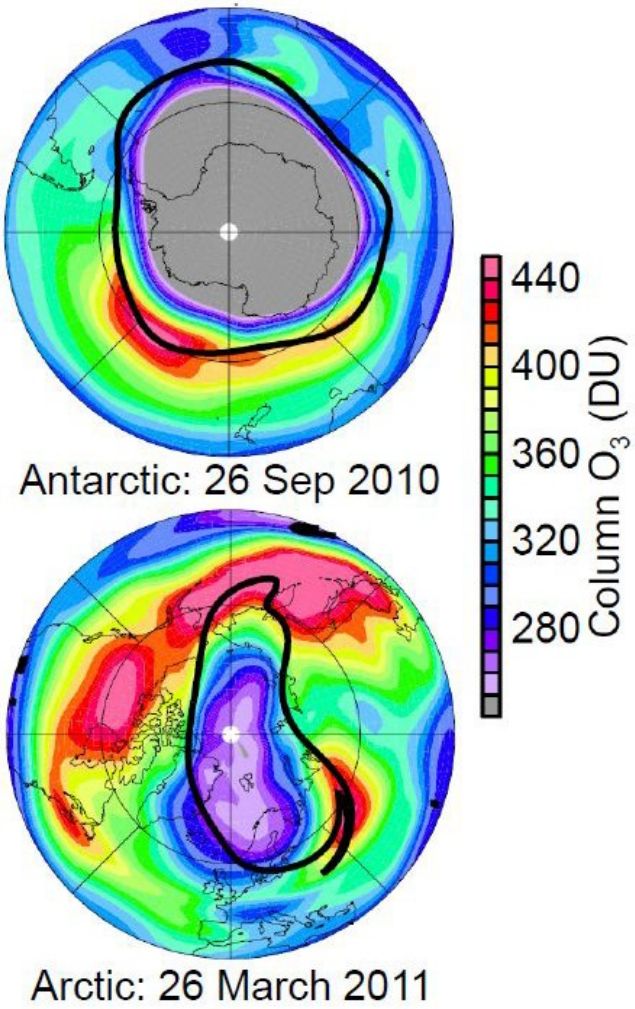


# polar ozone – more or less constant



# polar ozone – 2010 Arctic “hole”

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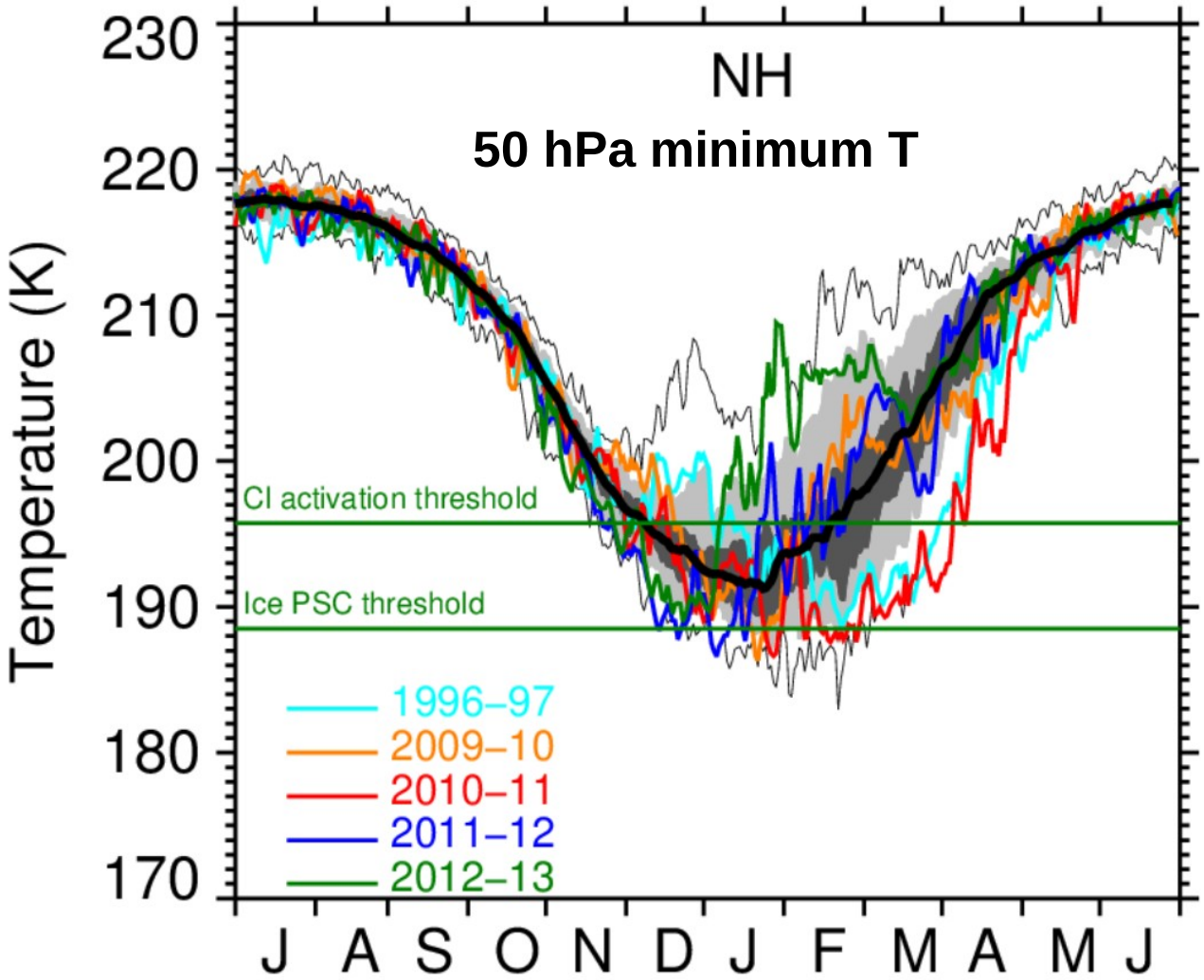
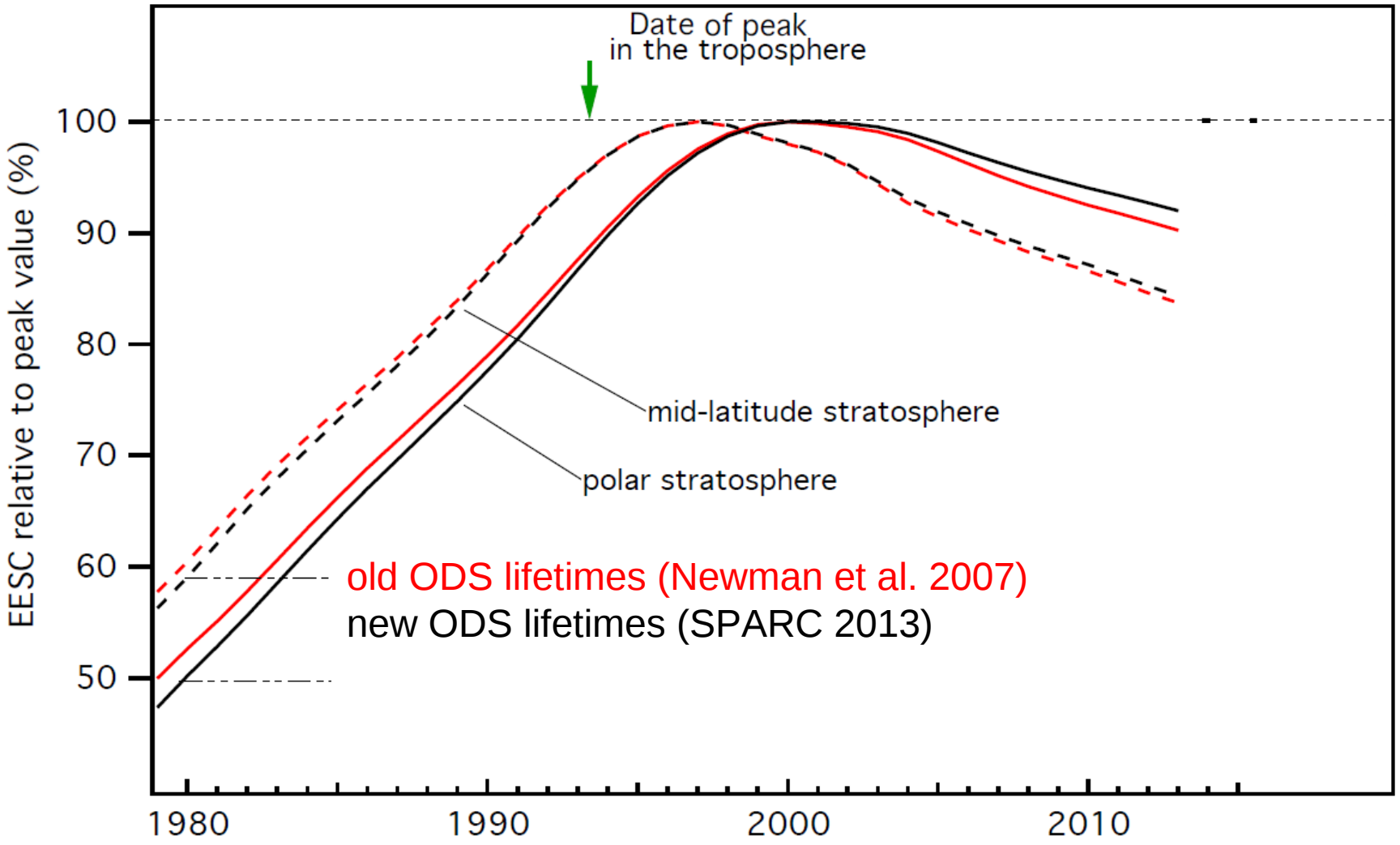
# polar ozone – 2010 Arctic “hole”



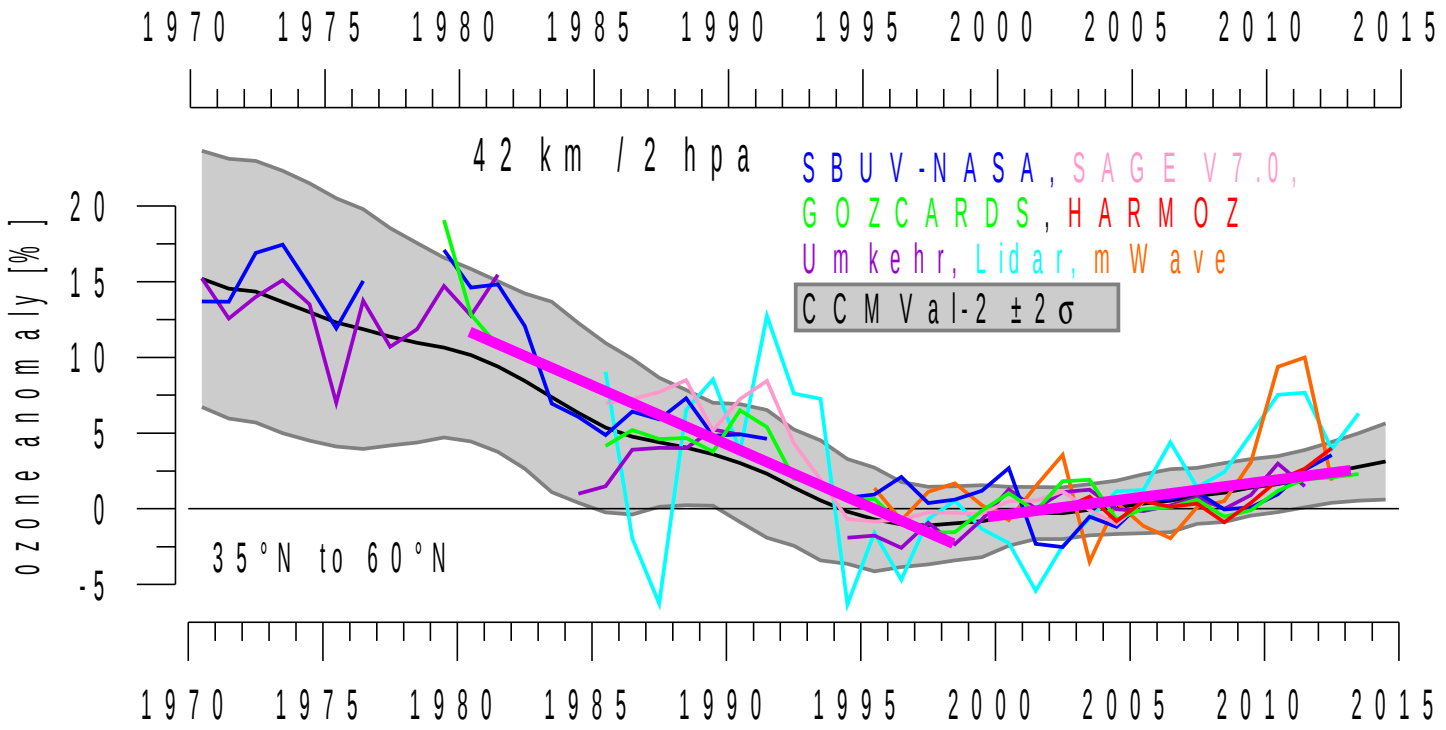

- unusually cold & stable vortex
- like 1997
- confirms understanding of chemistry
- could happen again while ODS are high

# Effective Equivalent Stratospheric Chlorine = EESC

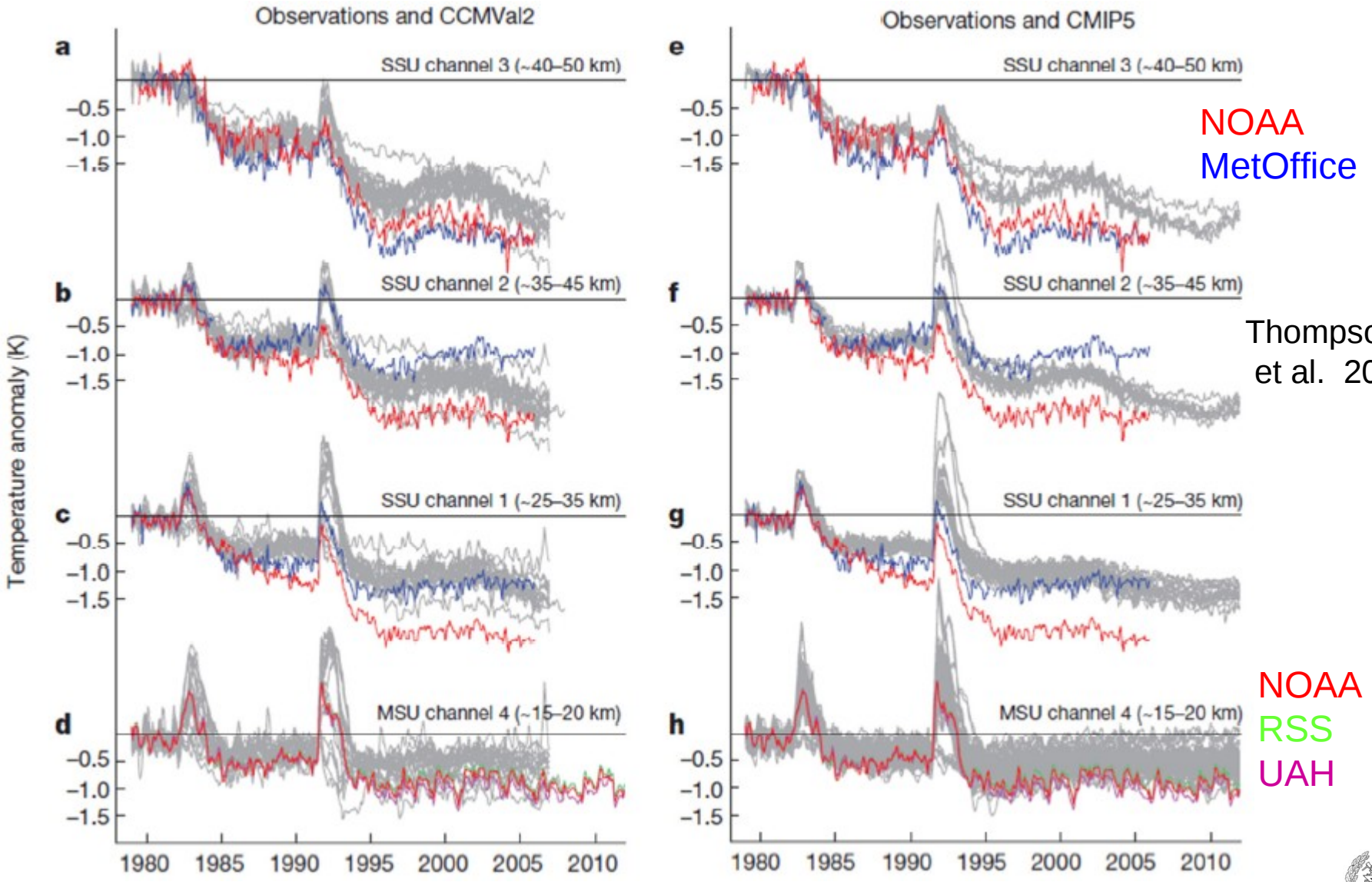


# Observed changes in ozone profiles

**upper stratospheric ozone** (35-45 km altitude)
**+2-3% per decade**



# stratospheric cooling due to $CO_2$ increase




NOAA
MetOffice

Thompson et al. 2012

NOAA
RSS
UAH

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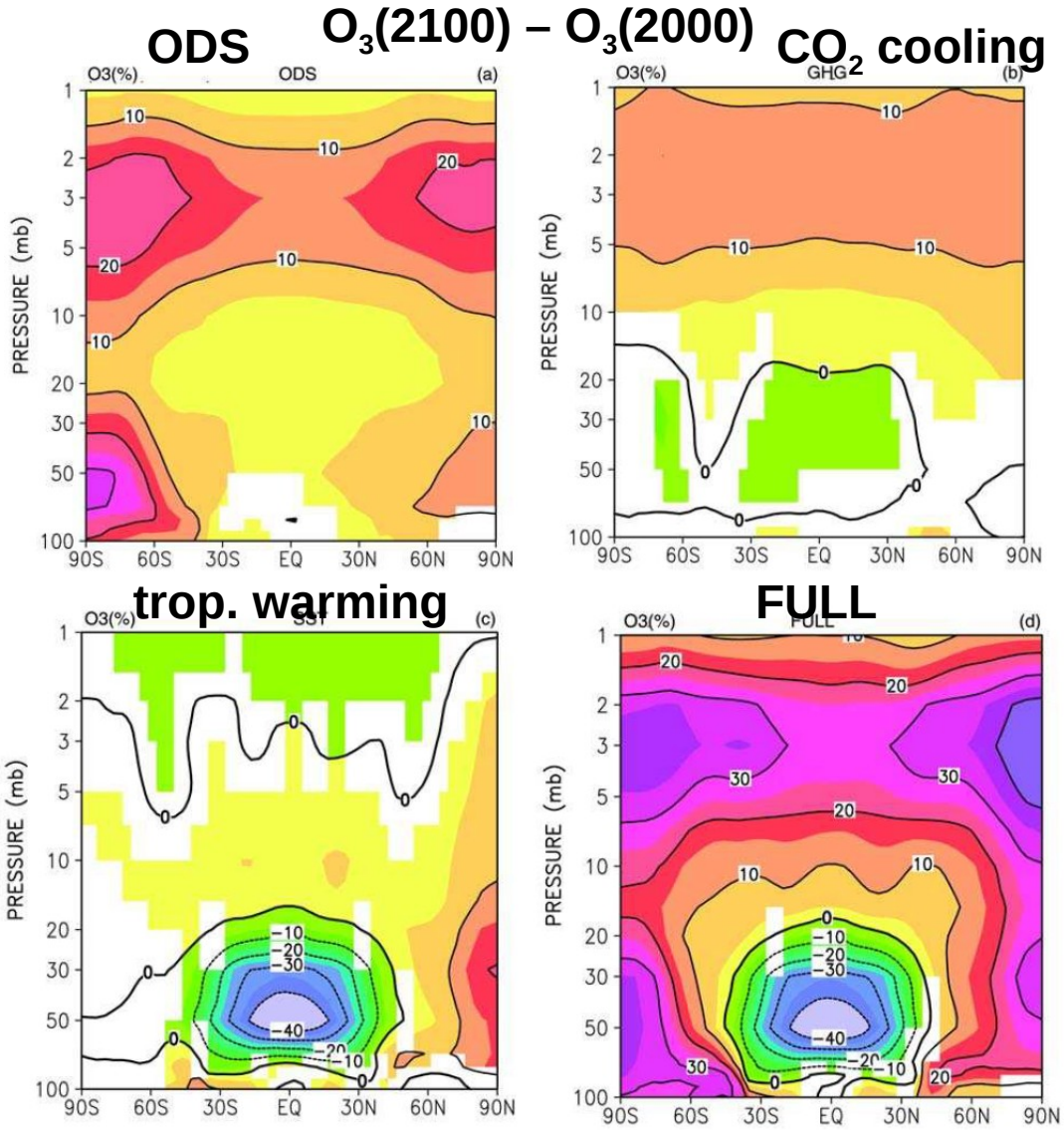
# drivers of future ozone changes

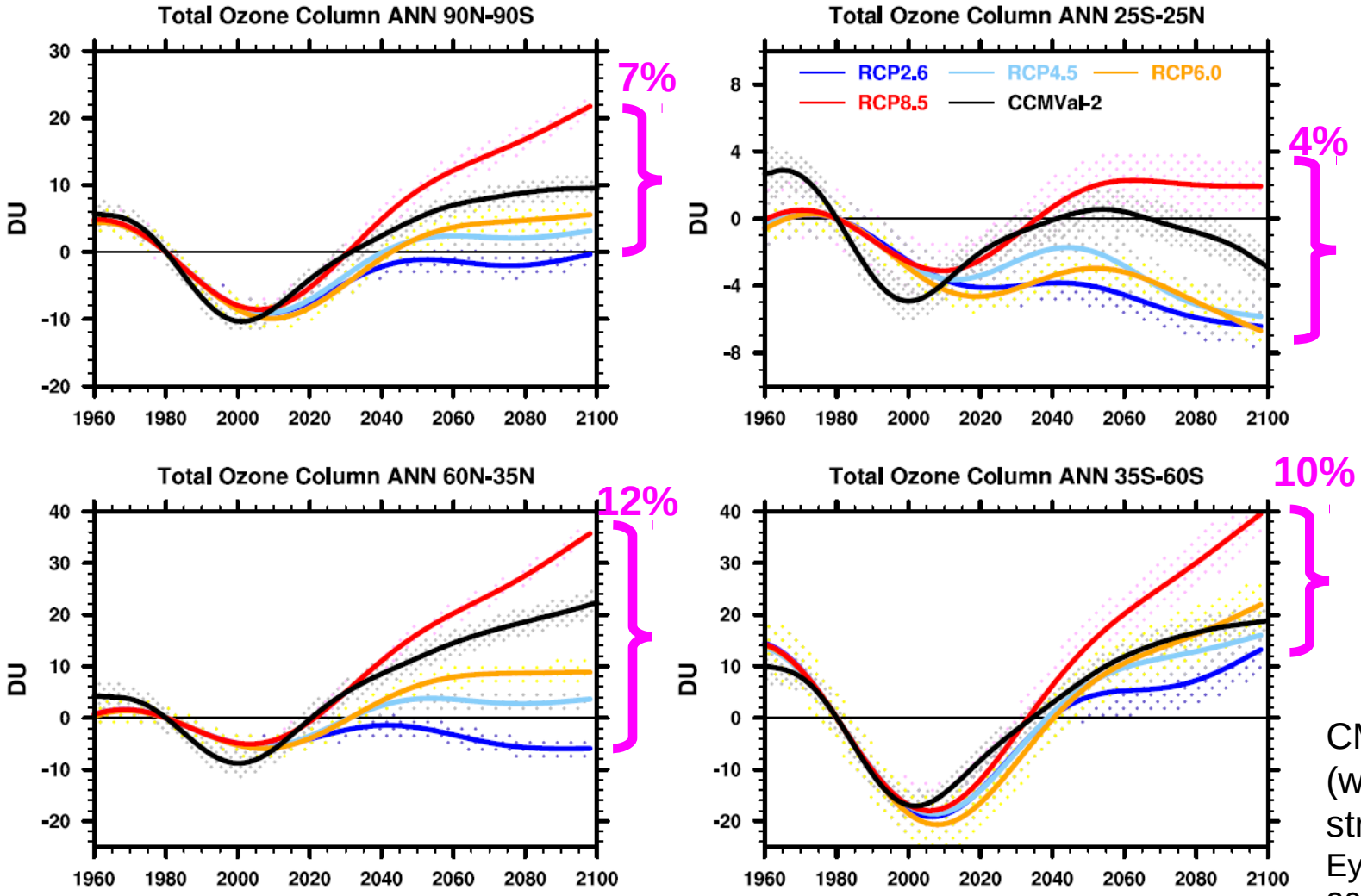
- Less ODS → more $O_3$
- more $CO_2$ → strat. cools → more $O_3$
- more GHG → troposphere warms → enhanced ascent in tropics → enhanced BDC
- larger ozone columns at higher latitudes
- smaller ozone columns in tropics?




Zubov et al. 2012

# future ozone changes

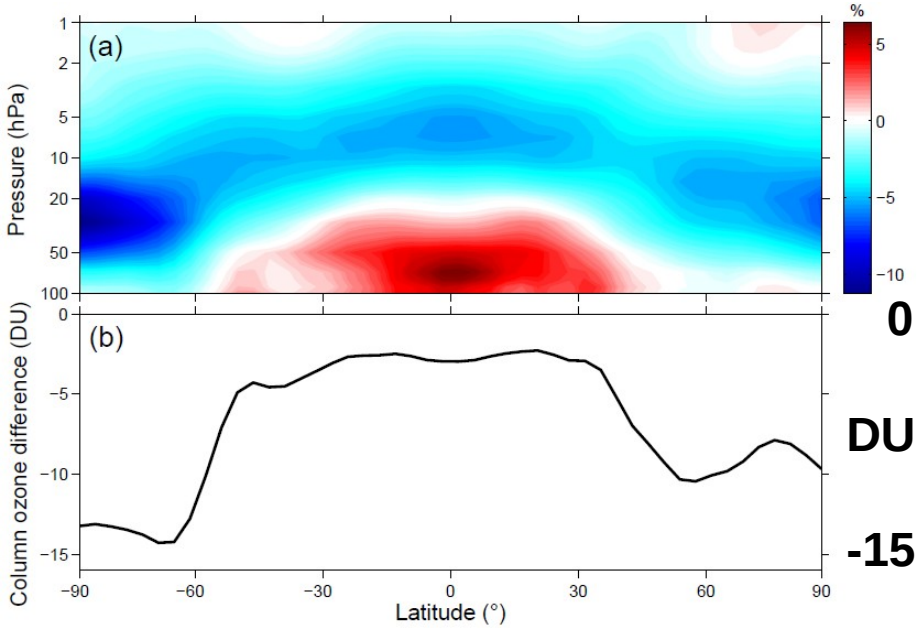
## large uncertainties (model + emission scenario)



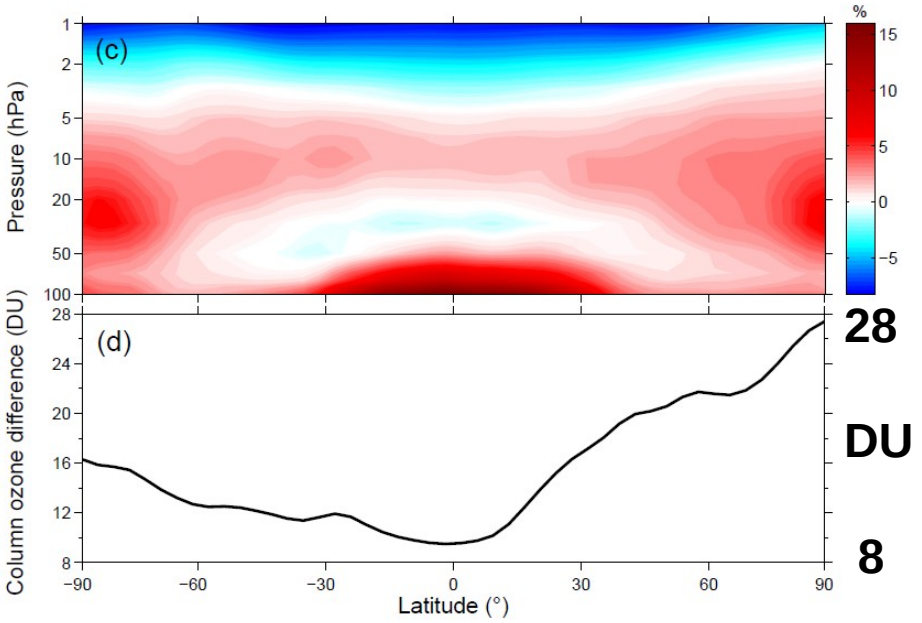

CMIP5 models (with ozone, stratosphere)
Eyring et al., 2013

# Future ozone changes $N_2O$, $CH_4$

**more $N_2O$ → less ozone**




**more $CH_4$ → more ozone**




**$N_2O$, $CH_4$**: RCP8.5 – RCP2.6 in 2090 **$CO_2$, other**: SRESA1B **ODS**: WMO 2007

Revell et al., 2012

# summary

- Ozone columns since 2010 level or even increasing
- Upper stratospheric ozone is increasing
- Montreal Protocol is working !!
- $CO_2$ → cooling → changes in Brewer-Dobson circulation → increases in ozone (not Tropics?, polar winter?)

- we expect ozone to increase, but
- $CO_2$, $N_2O$, $CH_4$ will all be important and will be interacting
- wide range (scenario, models)
- expected effects: magnitude ≈ past ODS effects

- need future monitoring
- need modelling efforts