Is ozone turning around?

Regional SPARC Science Workshop
IUP Bremen

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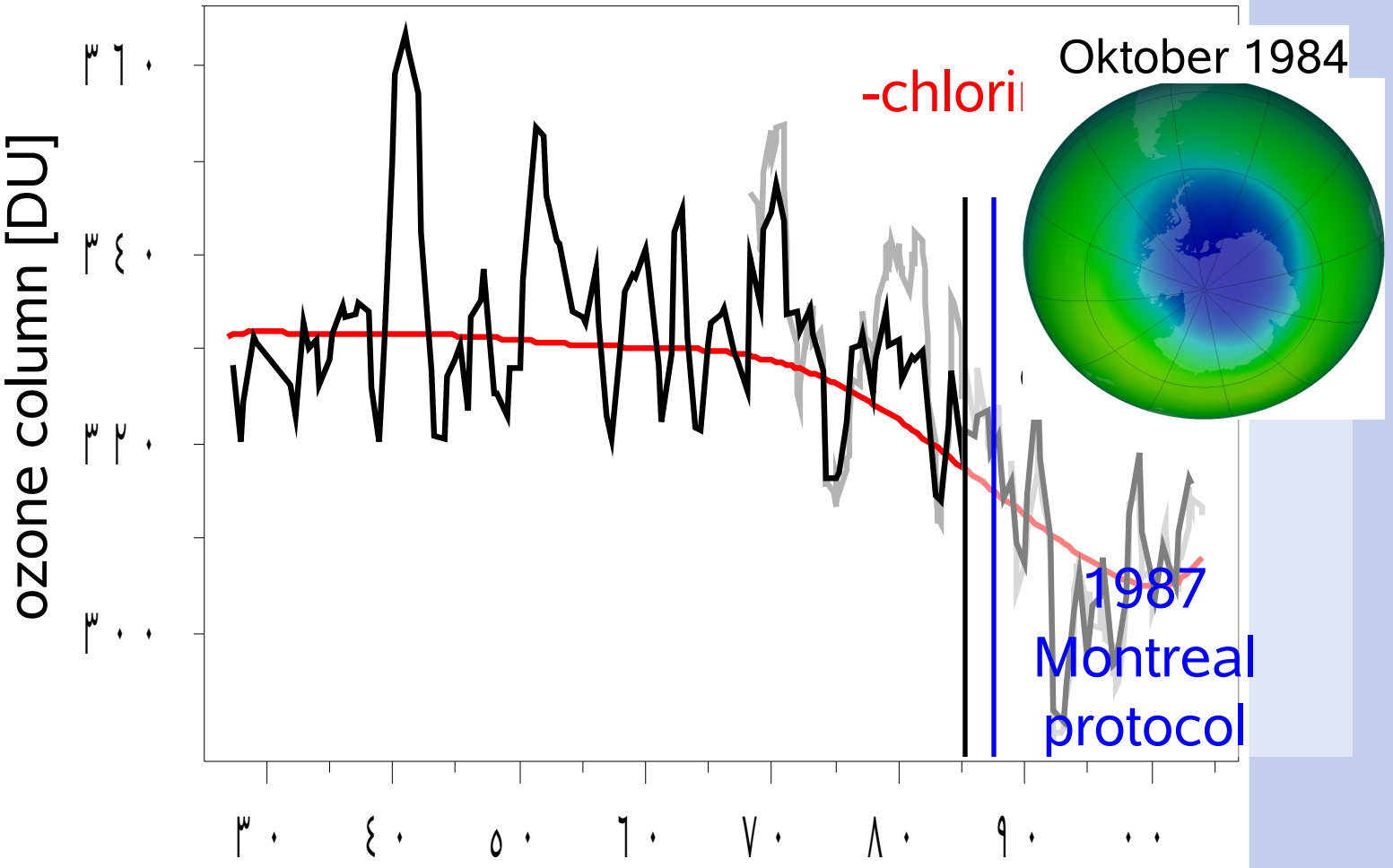
et al.!
Met. Obs. Hohenpeißenberg
Deutscher Wetterdienst

global ozone-decline

(Arosa, Dec to May)



http://www.iac.ethz.ch/en/research/chemie/tpeter/totozon.html

ozone vs. actions

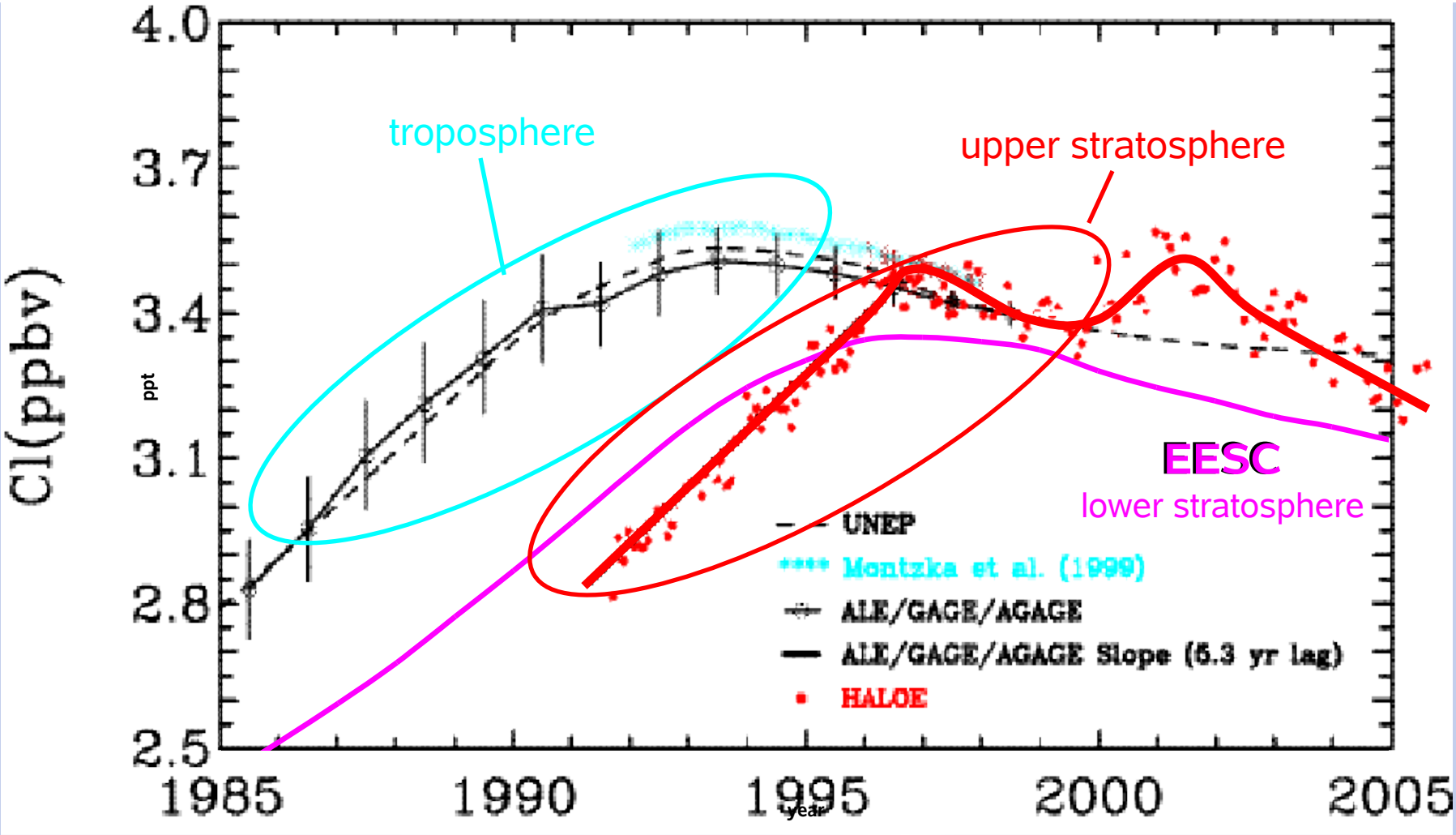
- ozone photochemically produced and destroyed
- ozone globally transported
- chlorine (and bromine!) from CFCs deplete ozone
  - global column by 4%
  - Antarctic ozone hole

∀≈1990 end of harmful CFC production (Vienna 1985, Montreal 1987, ..., Copenhagen 1992, ...)

- chlorine has started to go down (not bromine)

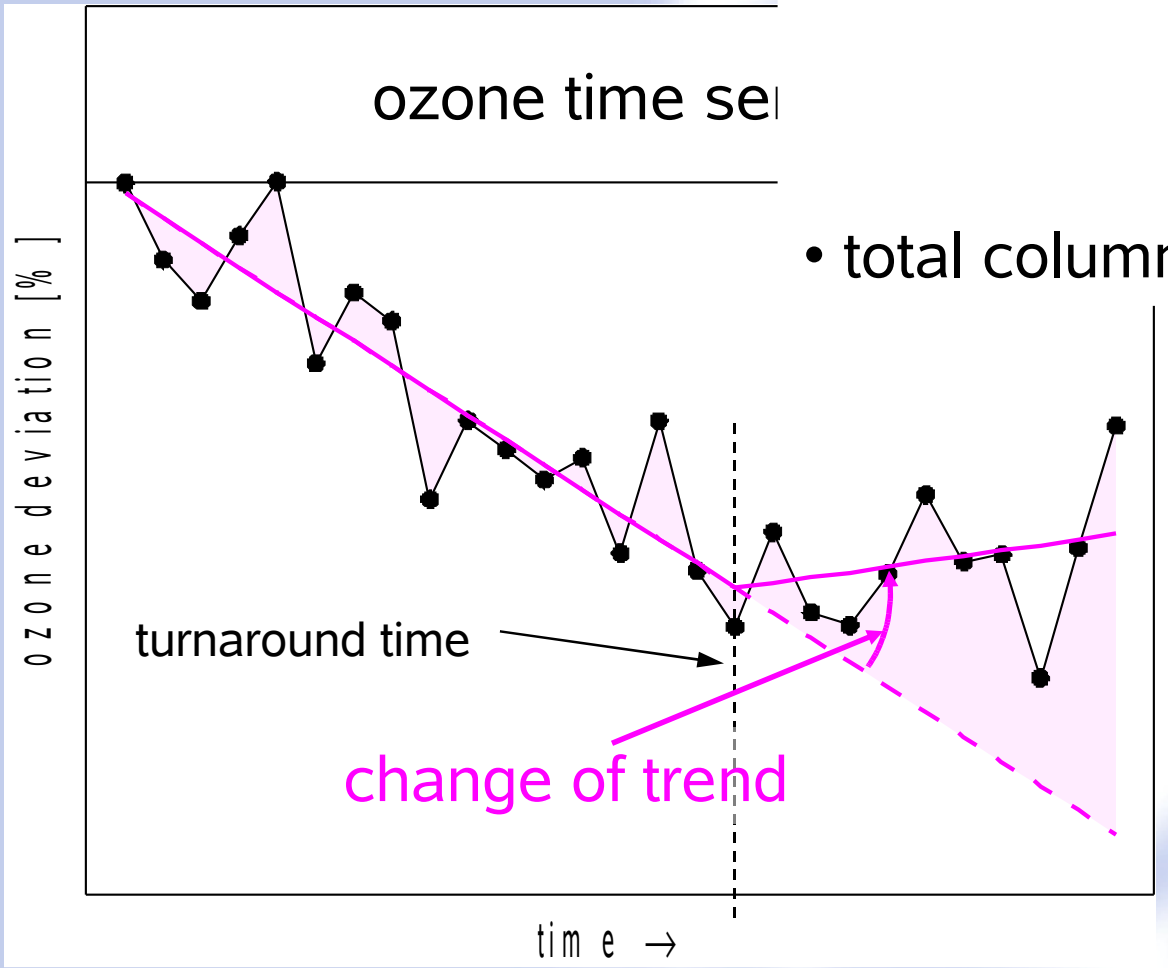
do we see positive effects on ozone?

chlorine has turned around



Anderson and Russell, QOS, 2004, updated

ozone turning?



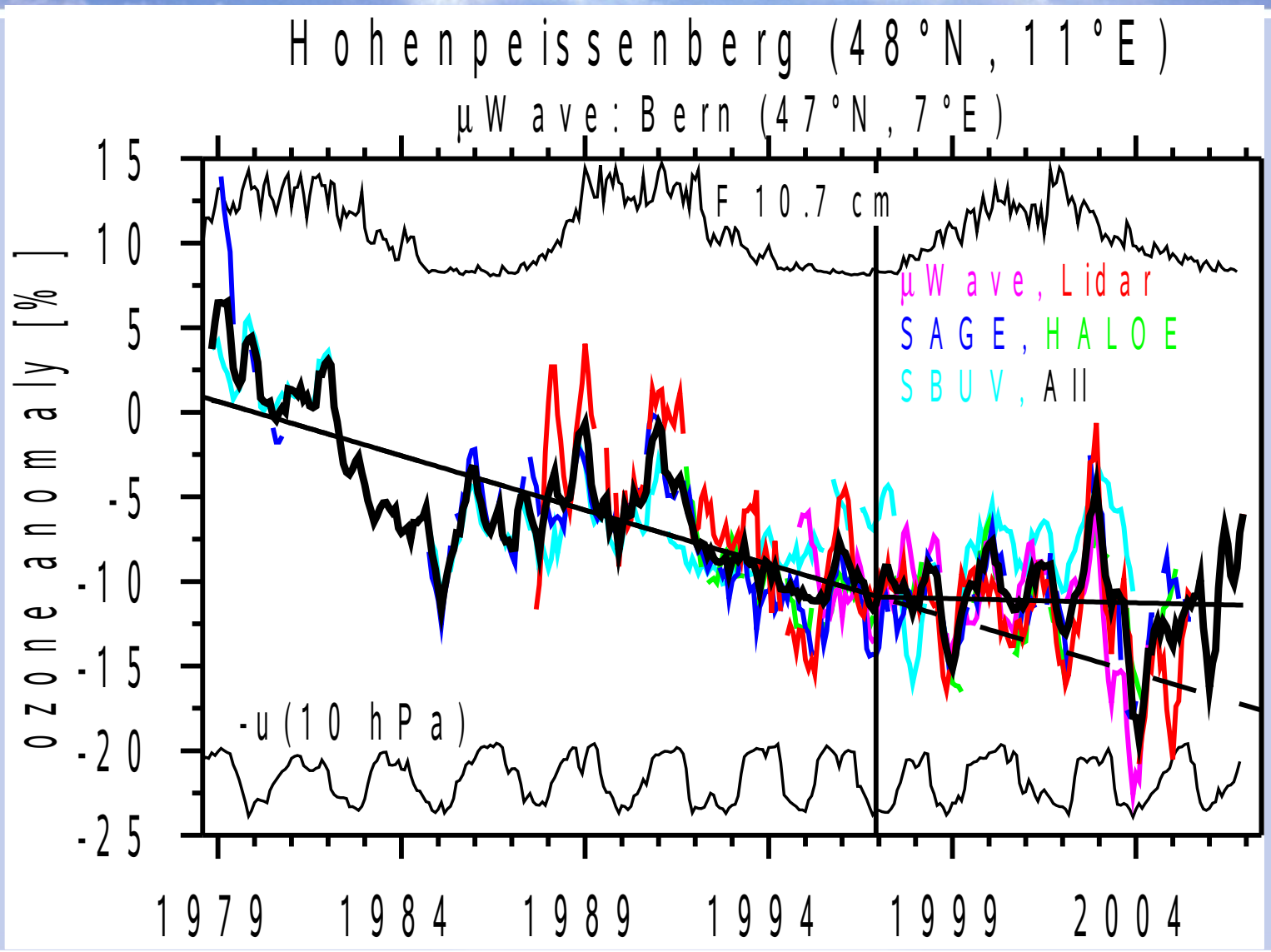
- upper stratosphere?

photochemical control
solar cycle
QBO

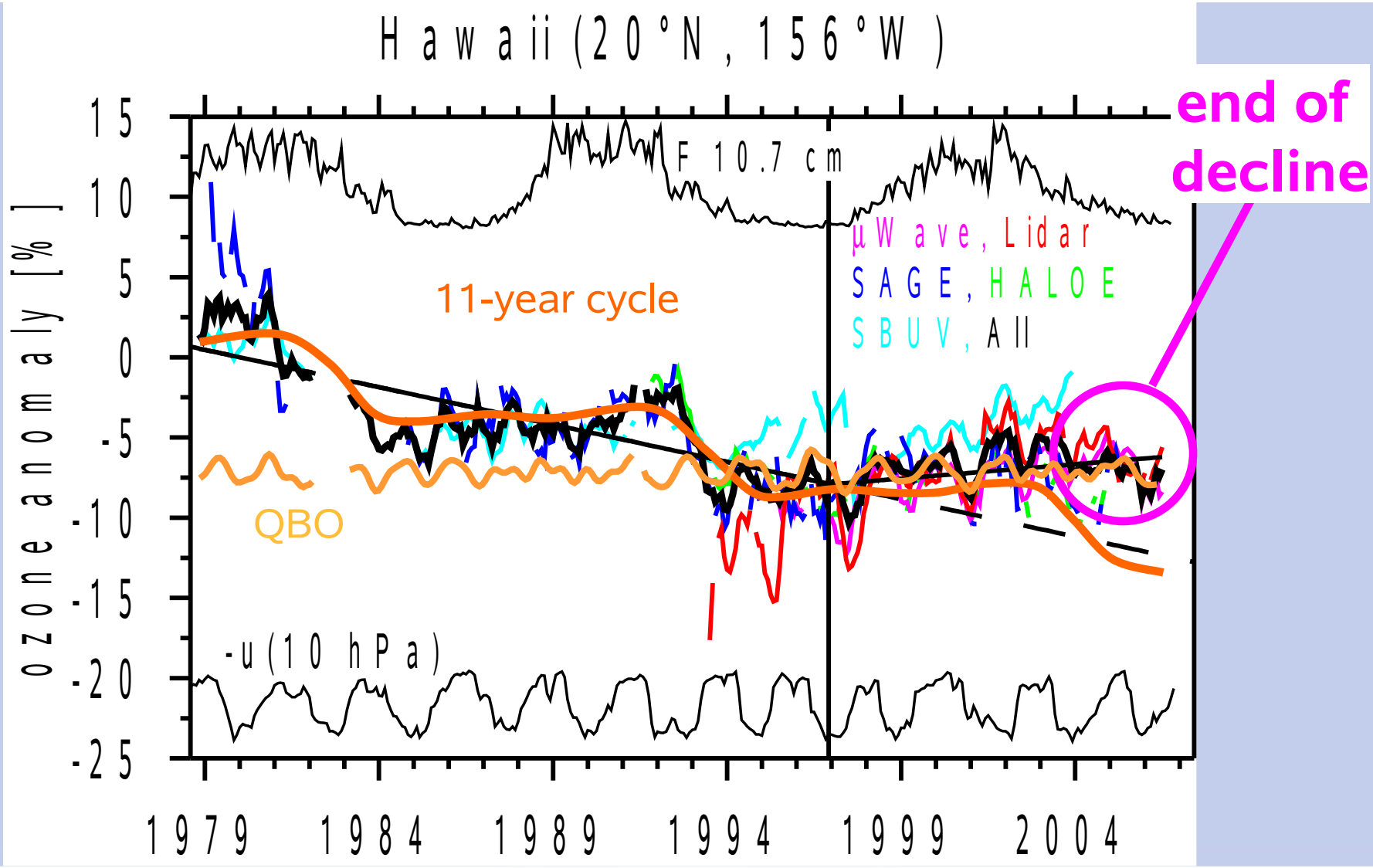
- total column?

transport + chemistry
solar cycle
volcanoes
QBO
NAO/ AO
...

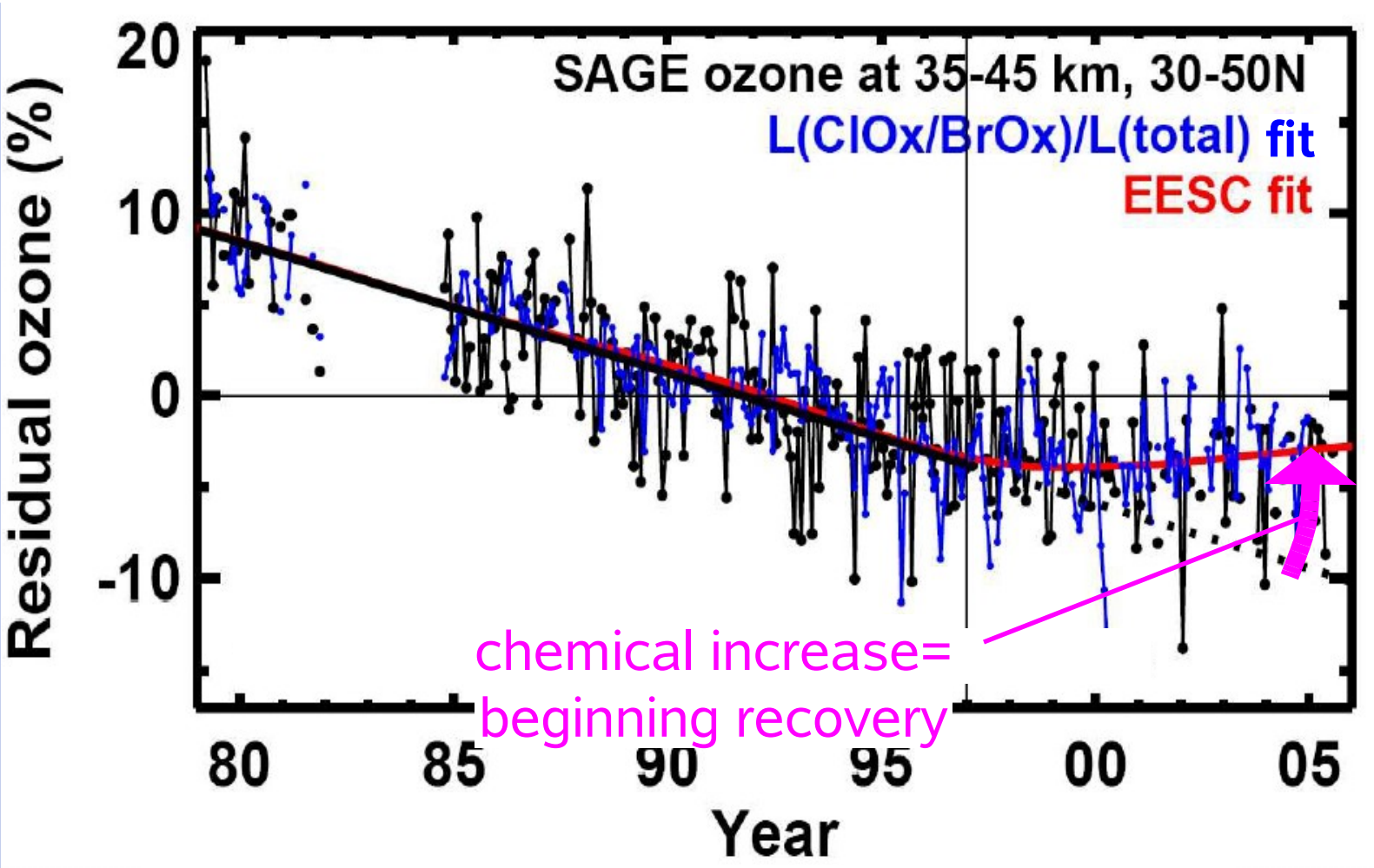
upper stratosphere (35 to 45 km)



solar cycle (and QBO)



upper stratosphere

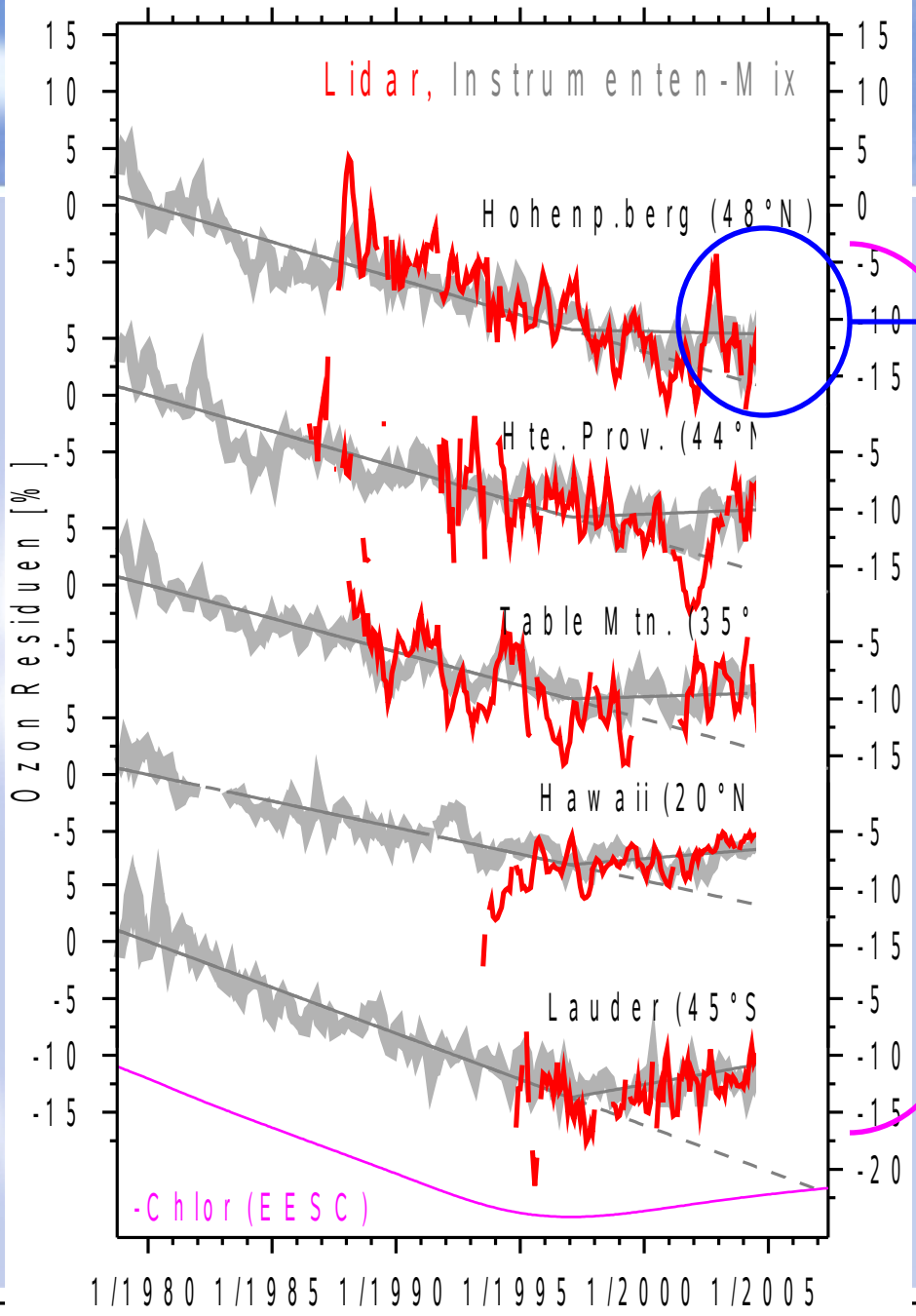


Newchurch et al., JGR, 2003; Yang et al., JGR, 2006

5 NDSC stations

QBO and solar-cycle removed

Steinbrecht et al., JGR, 2006



temperature?

getting better

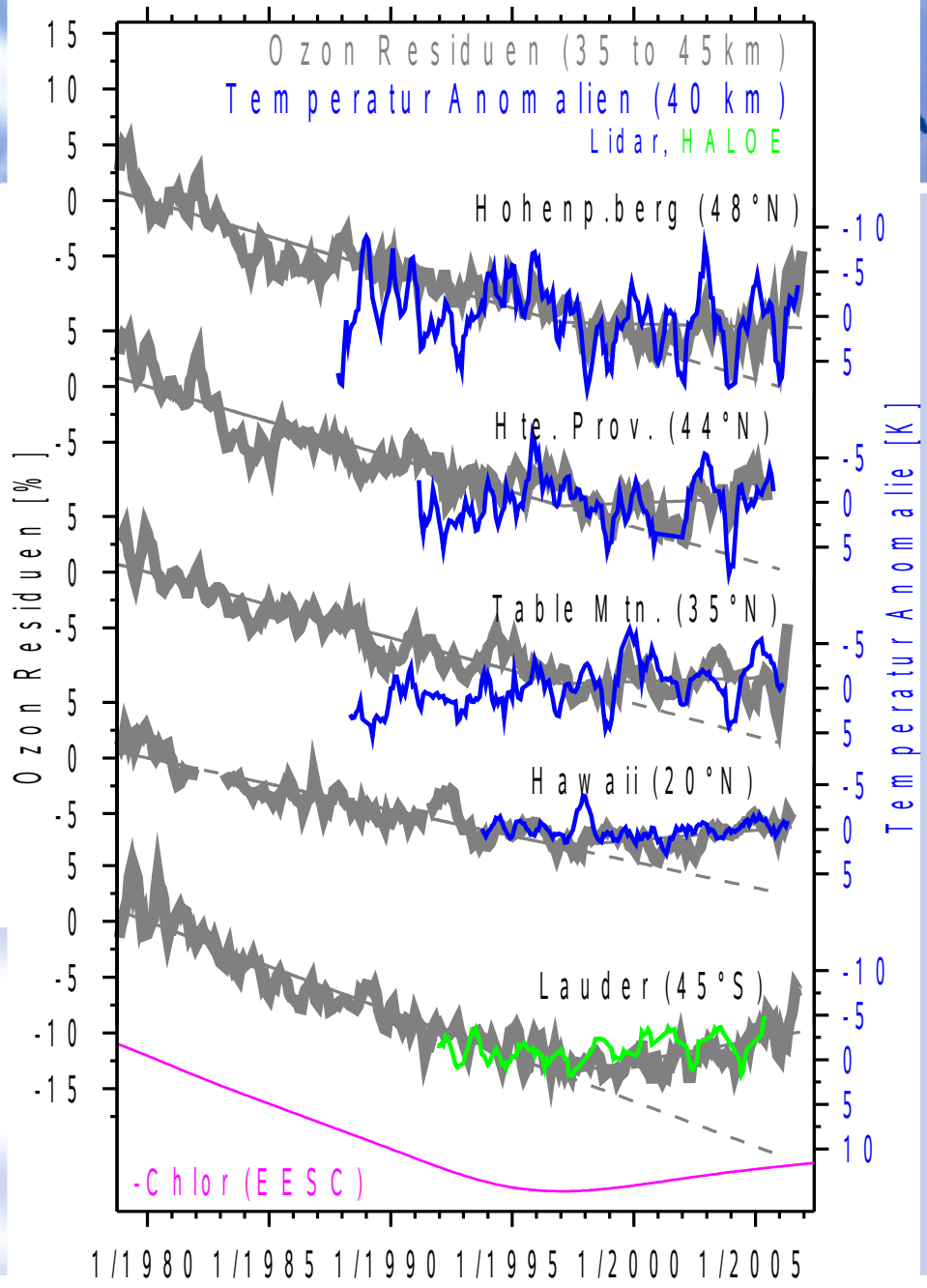
temperature?

neg. temperature dependence of

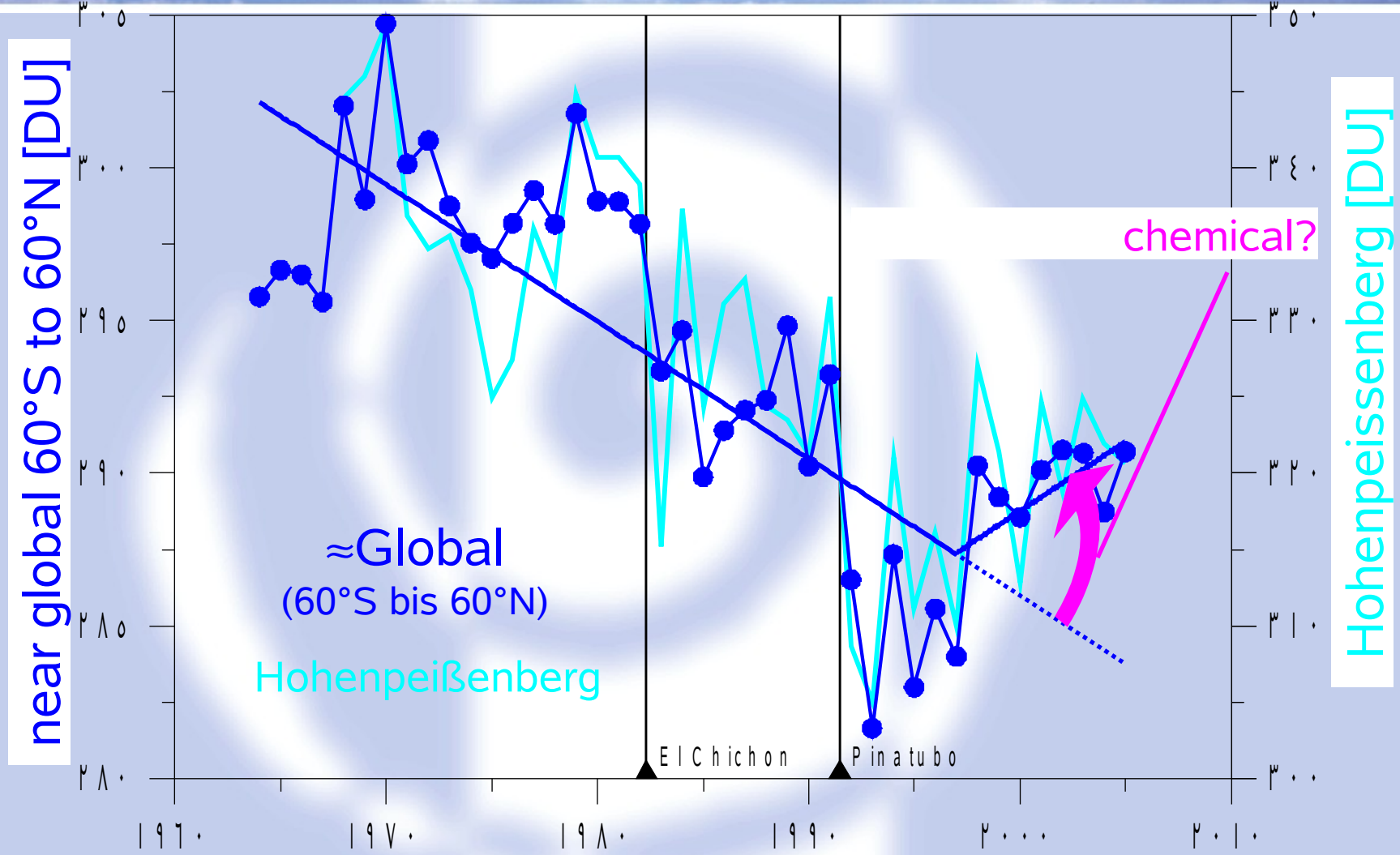
$O_3 + O \rightarrow 2\ O_2$

=>

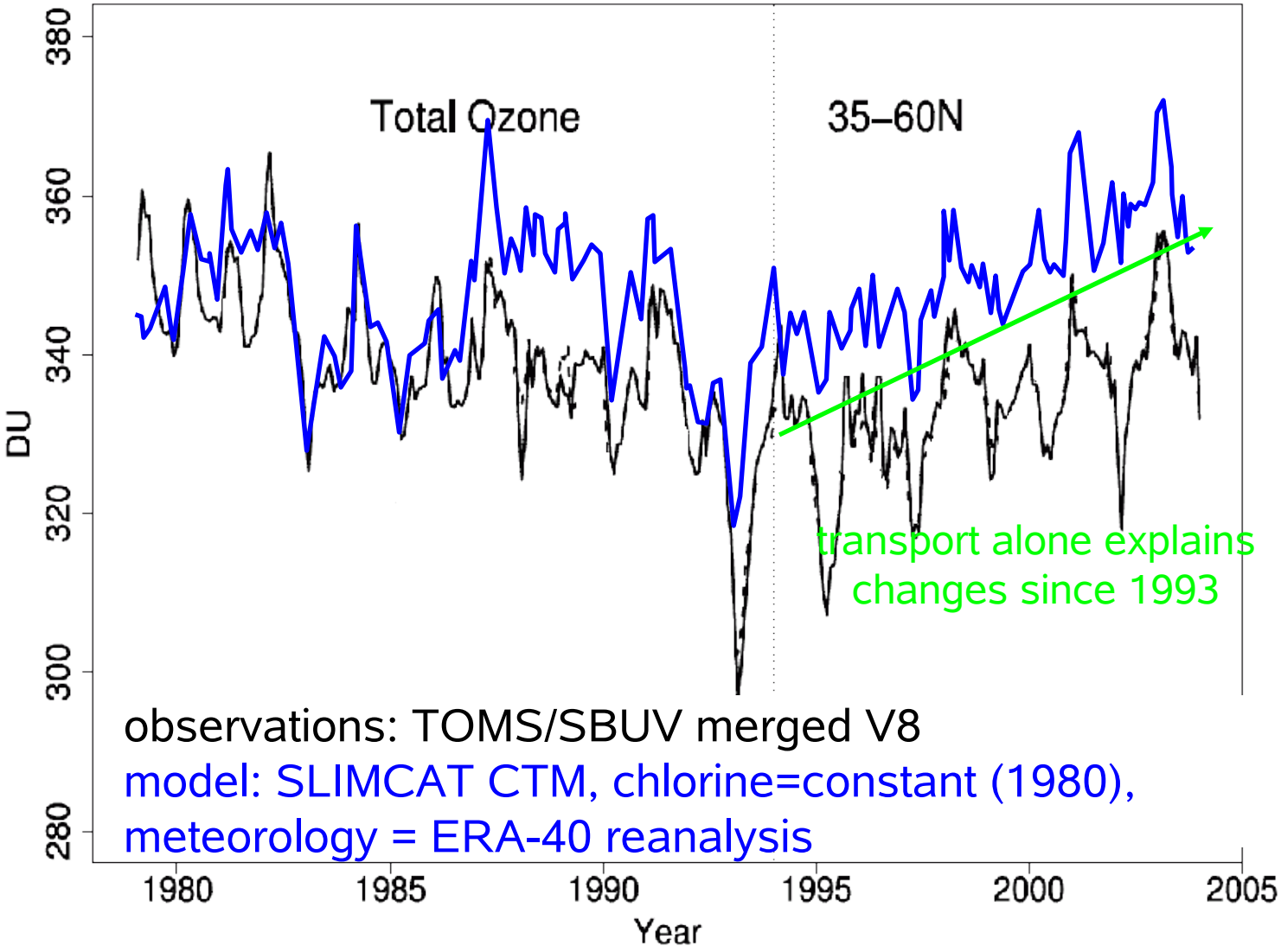
-1% ozone / Kelvin temperature increase



total column ?



transport changes?



Hadjinicolau, GRL, 2005

or chemistry?

Yang et al., JGR, 2006:

altitude-distribution (30°N bis 50°N)

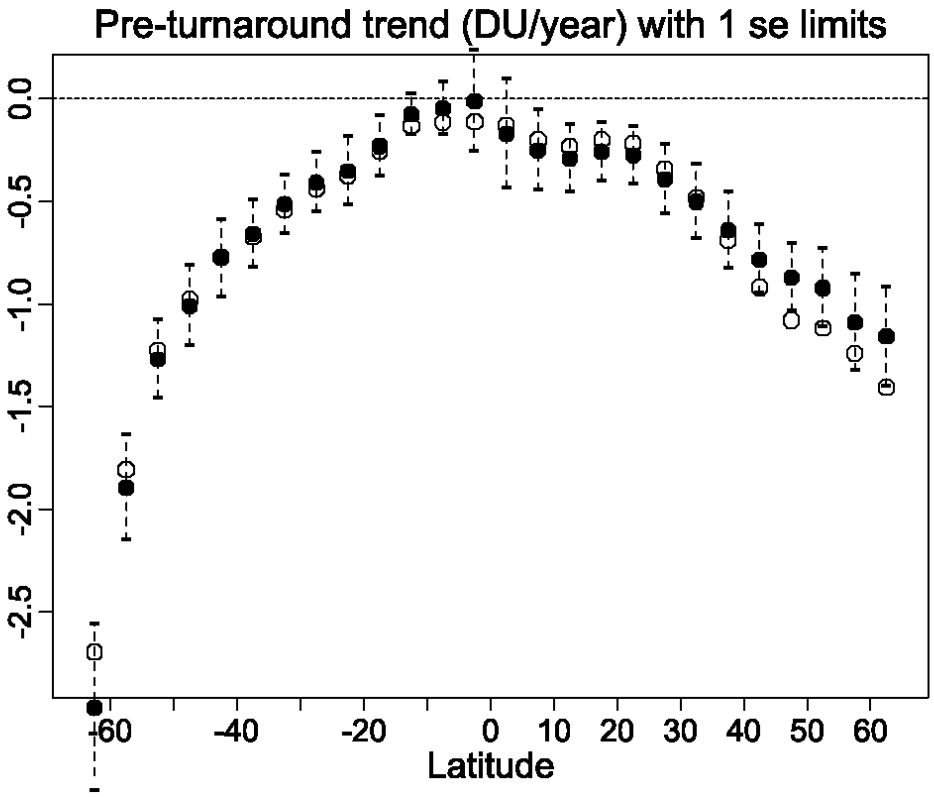
altitude range	fraction (1979 bis 1997)	**fraction (1997 bis 2005)**	**attribution**
above 18 km	80% ± 12%	54% ± 25%	chemistry
tropopause to 18 km	20% ± 14%	46% ± 29%	transport

large error bars !

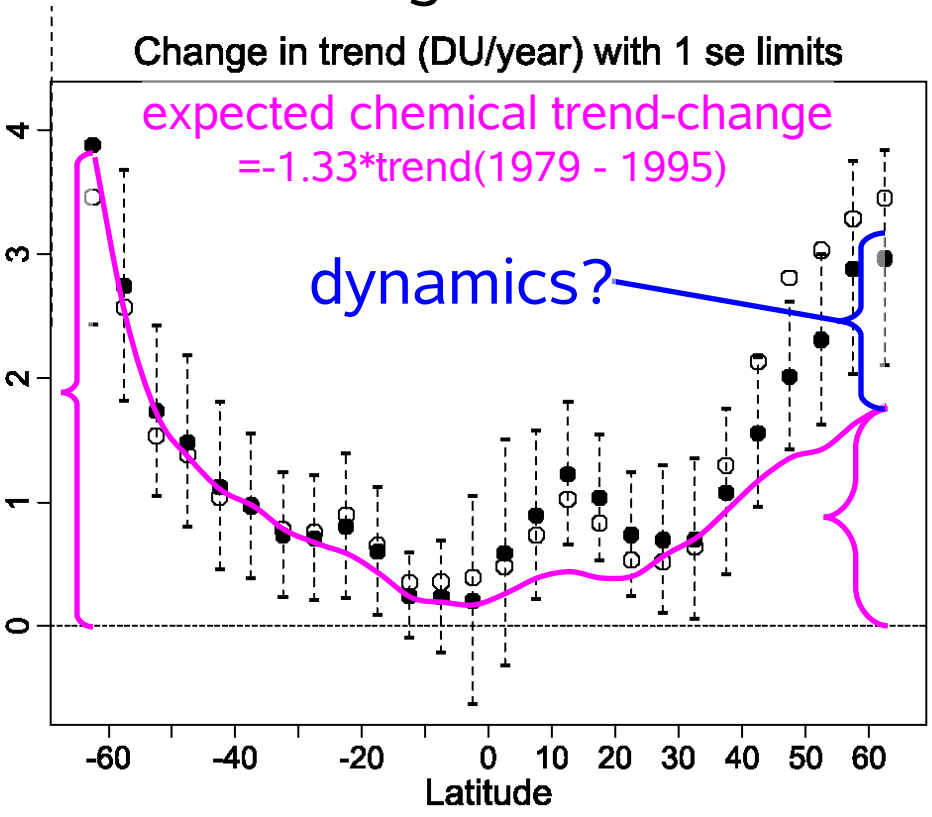
see also: Dhomse et al., ACP, 2006; Stolarski and Frith, ACP, 2006; Brunner et al., ACPD, 2006 ; Wohltmann et al., JGR, 2007;

latitude dependence

trend 1979 - 1995



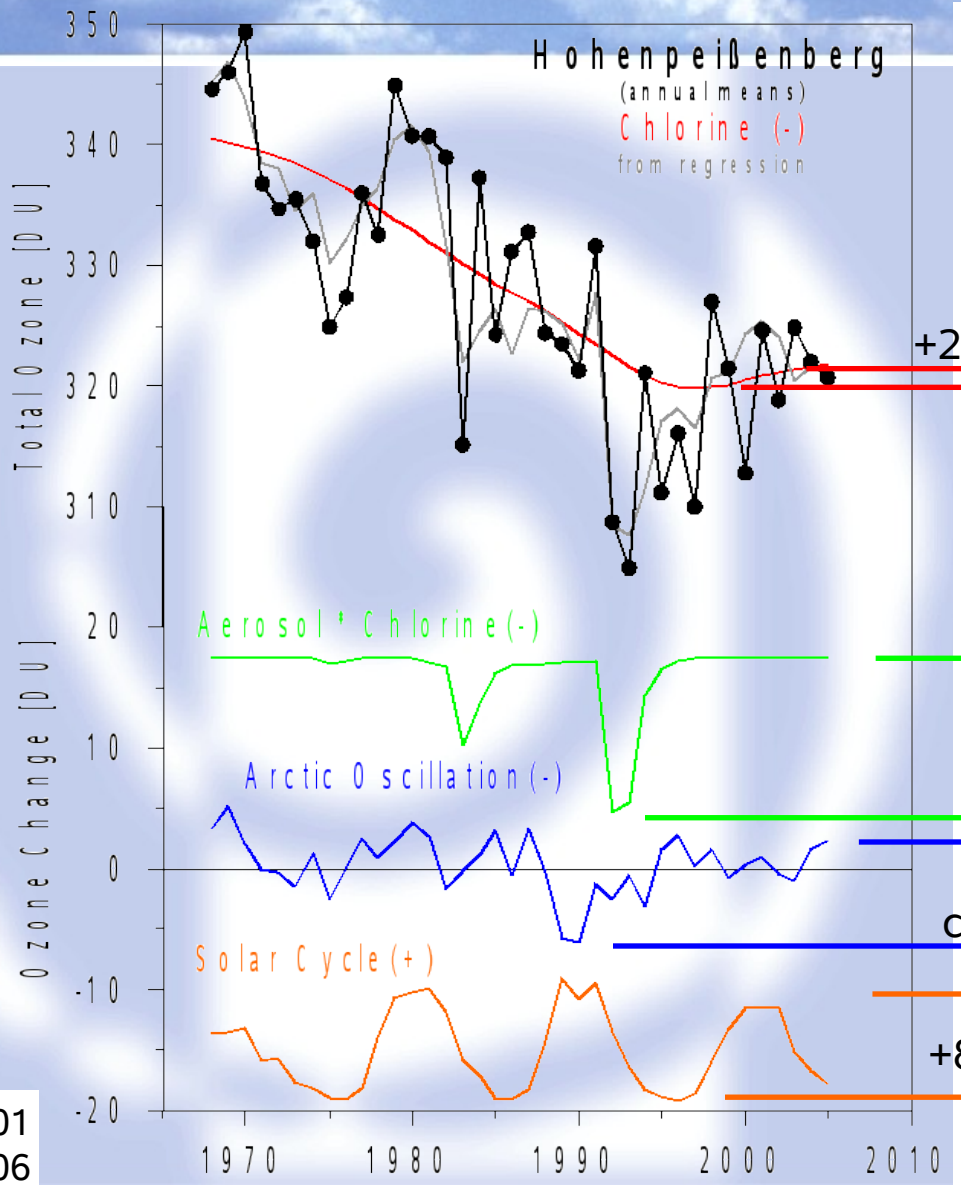
trend-change 1996 - 2002



G.C. Reinsel et al., JGR, 2005. **TOMS/SBUV merged V7. not 1992-1993.**

Open: without AAO/EP Full: with AAO/EP

chlorine just one factor!



+2 DU EESC

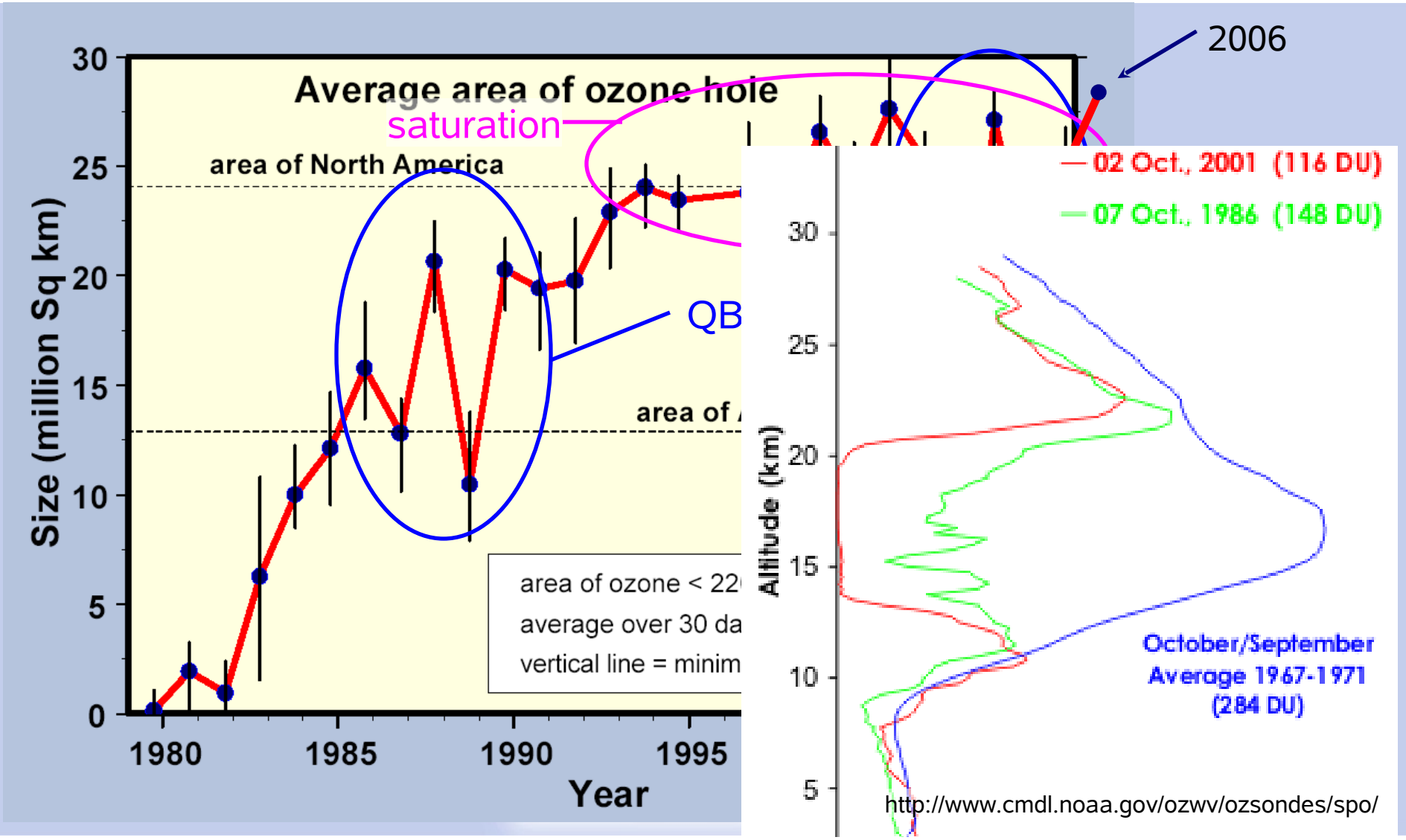
+13 DU aerosol

+8 DU circulation

+8 DU solar

Steinbrecht et al., GRL, 2001
Steinbrecht et al., ACP, 2006

antarctic ozone hole



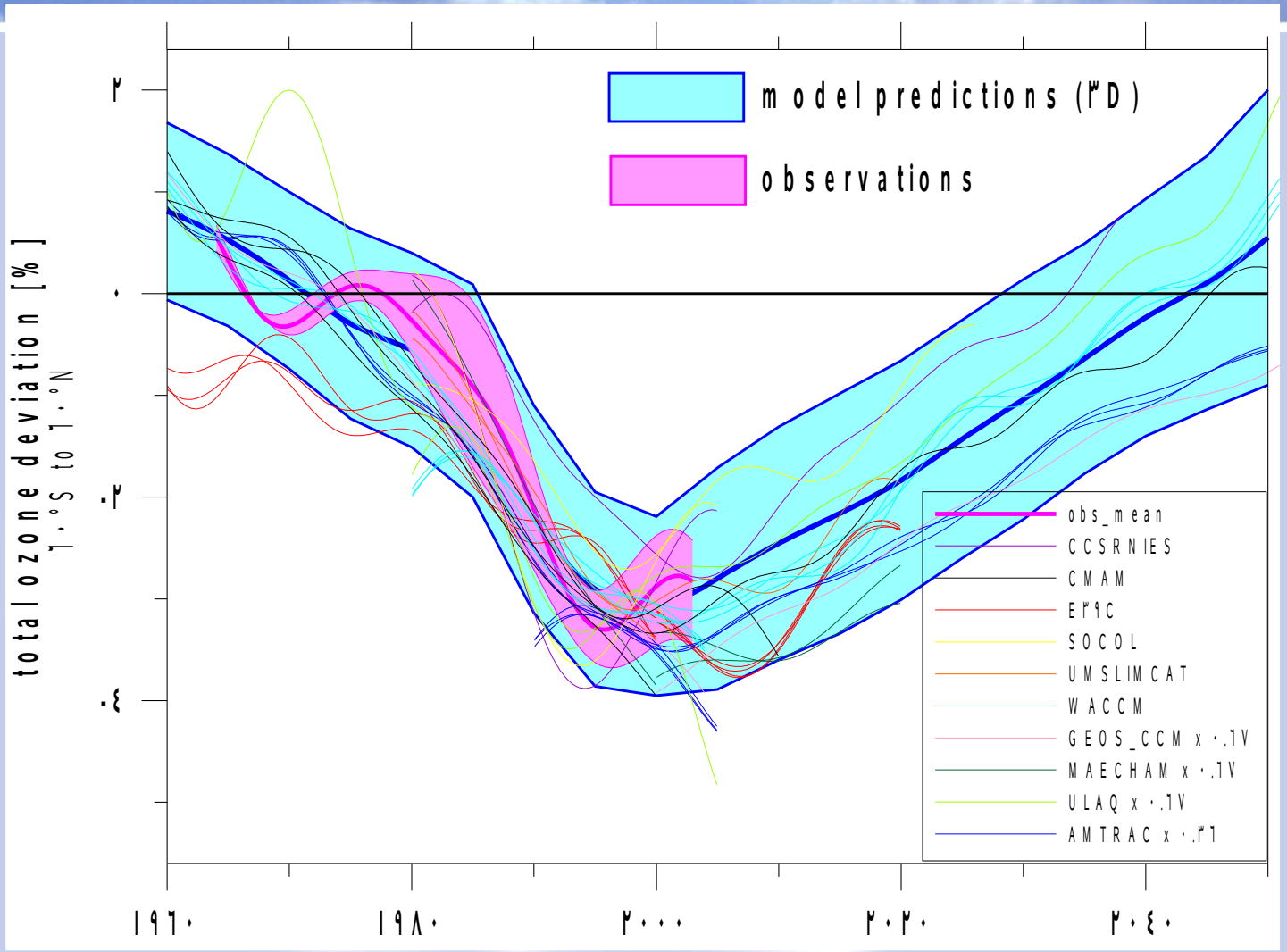
http://www.wmo.int/web/arep/gawozobull06.html

present

- chlorine has turned around
- we can see chemical improvement in upper stratosphere
- total ozone has been increasing in recent years
- > 50% transport, post-Pinatubo, solar cycle
- « 50% due to chlorine beginning to decline
- chlorine near maximum - ozone remains vulnerable (volcano, cold arctic winters, ozone hole at least until 2040)

chlorine is still very high

future



Ch. 6, WMO Assessment 2006, http://www.pa.op.dlr.de/CCMVal/index.html

future

- return to ,,pre-anthropogenic chlorine'' not before 2050!

  chlorine is still very high

- **climate change** ($CO_2 \uparrow$ $CH_4 \uparrow$)
  - warming troposphere: **transports change**
  - cooling stratosphere: more ozone in upper stratosphere

    cold & stable arctic vortex?

    less O_3 in lower stratosphere
  - NO_x, CH_4, (H_2O) are increasing $\rightarrow$ $O_3 \downarrow$
- **2060 ozone profile different from 1970**
- **more total ozone than in 1980 (Super-Recovery)**
- **consequences ?**

Executive summary

Montreal protocol ☑

but climate change ⇔ ozone change **! SPARC !**

Kyoto protocol ??