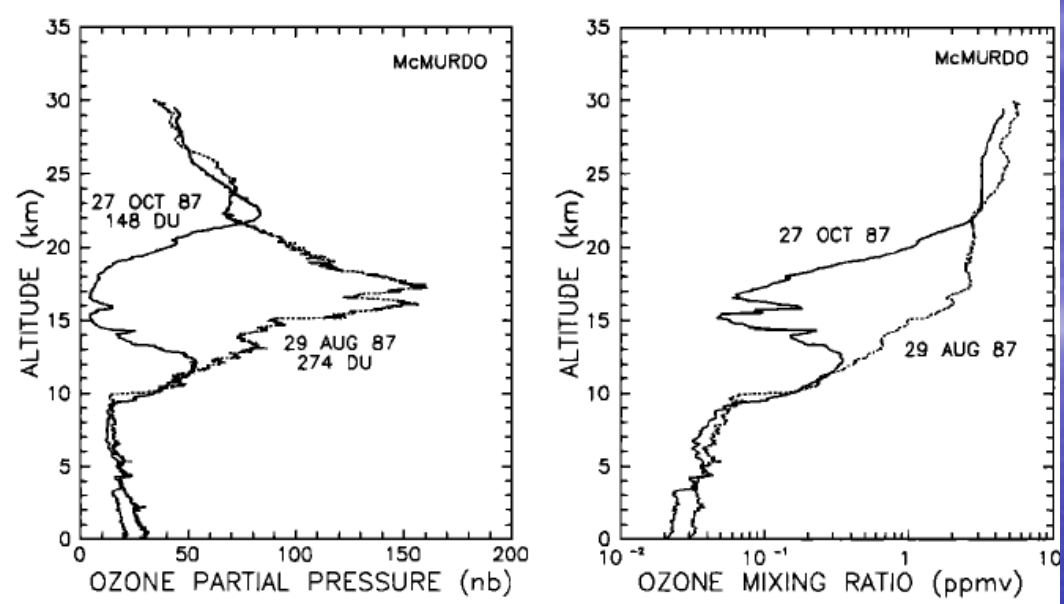
Stratospheric Ozone Changes
(an integrating theme of Dave Hofmann's research)

Sam Oltmans, Bryan Johnson, Joyce Harris,
Robert Evans, Irina Petropavlovskikh, Dorothy Quincy
NOAA Earth System Research Laboratory
Boulder, Colorado

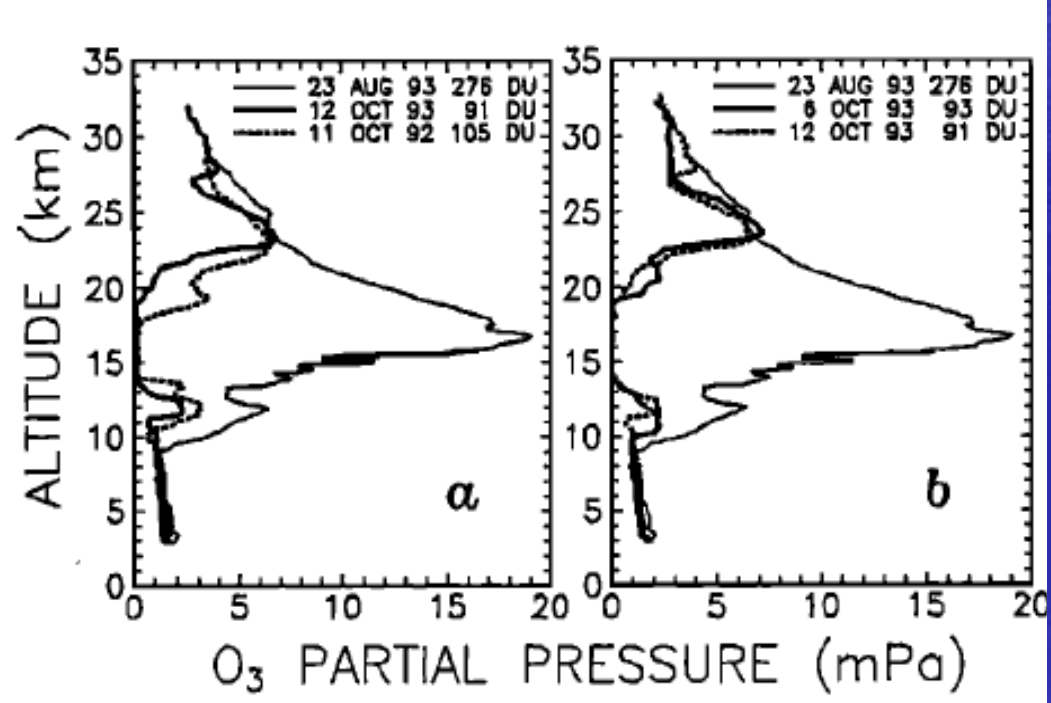
What this presentation is about

- Introduction (stratospheric ozone change at the heart of Dave's research)
- Changes in the Antarctic (South Pole)
- Mid latitude trends

Antarctic Ozone Depletion

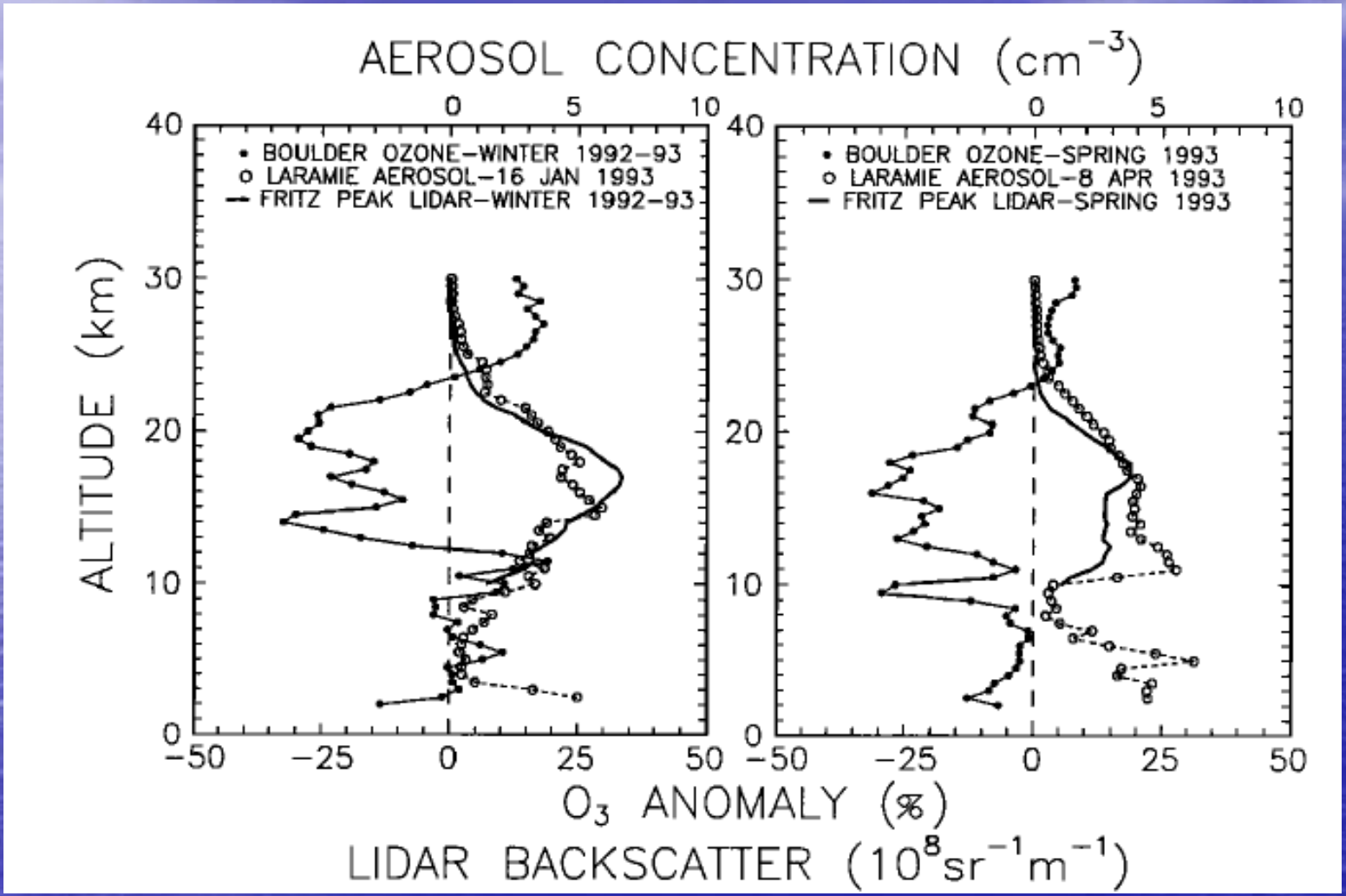


Hofmann et al. (1989) Ozone profile measurements at McMurdo Station, Antarctica during the spring of 1987, J. Geophys. Res.



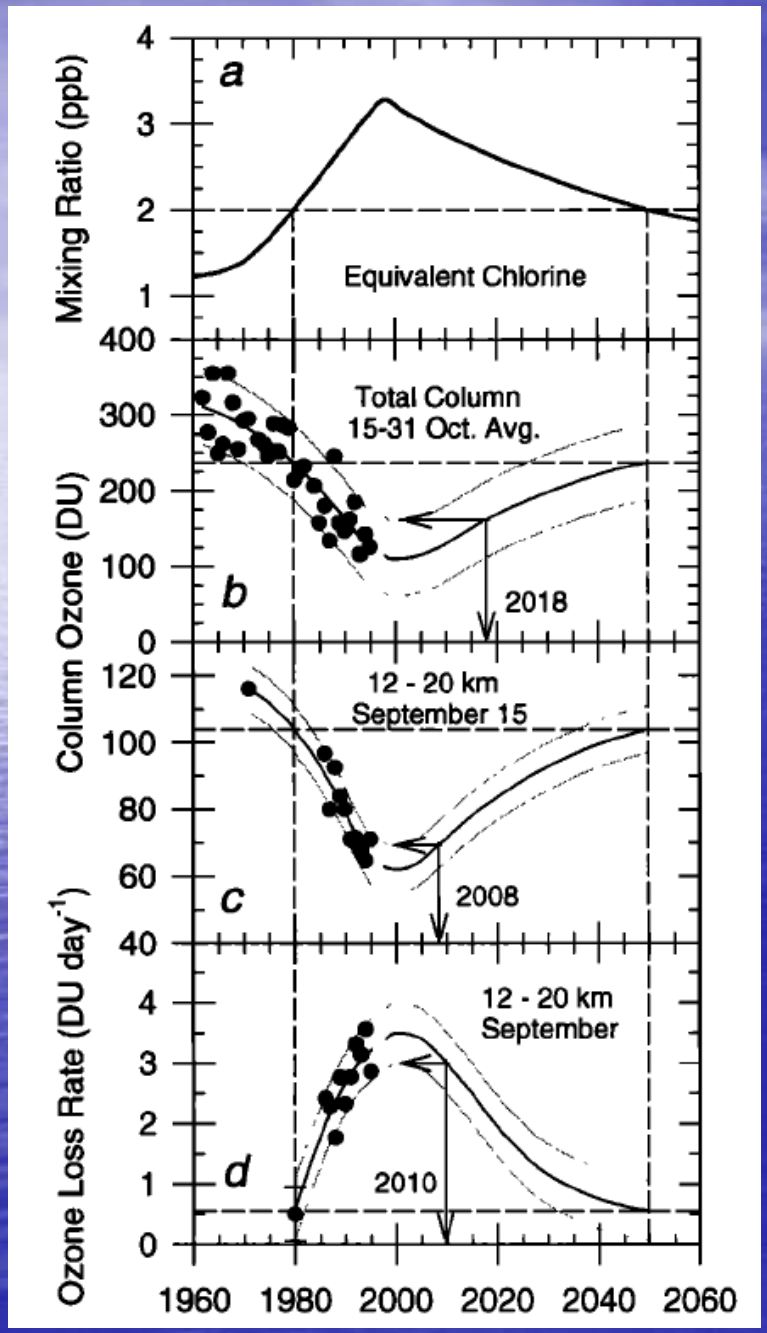
Hofmann et al. (1994) Record low ozone at the South Pole in the spring of 1993, J. Geophys. Res.

Volcanic Aerosol & Ozone Depletion



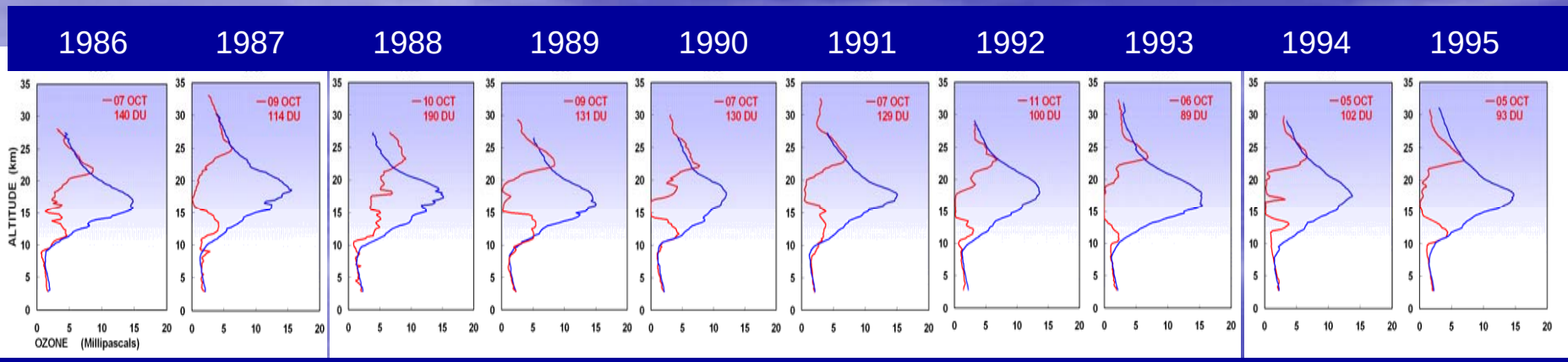
Hofmann et al. (1994) Ozone loss in the lower stratosphere over the United States in 1992-1993: Evidence for heterogeneous chemistry on the Pinatubo aerosol, Geophys. Res. Lett.

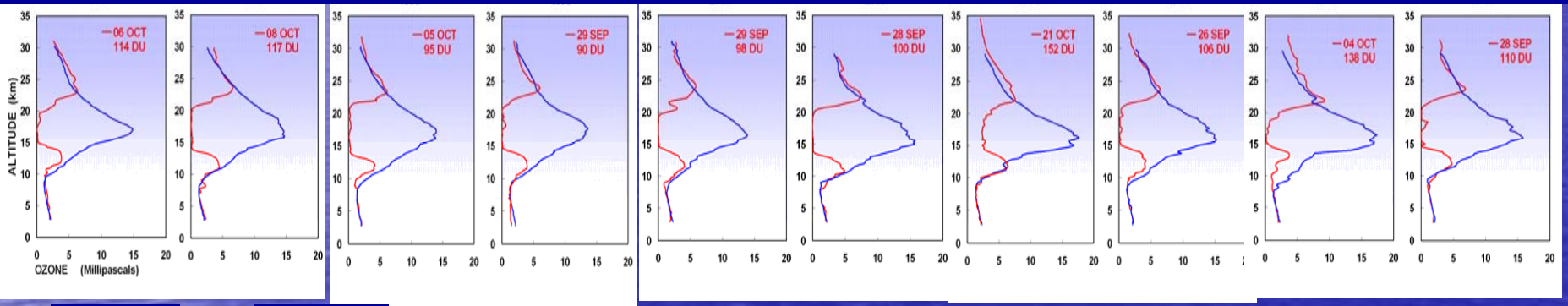
Ozone Layer Recovery

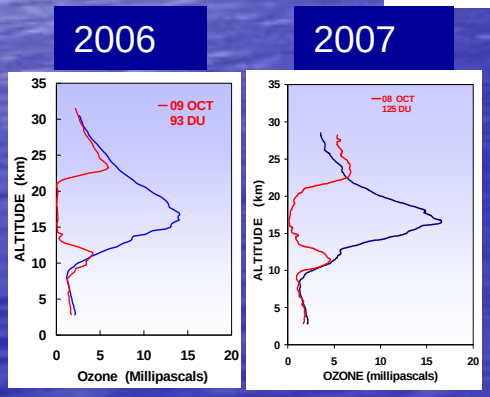


Hofmann et al. (1997) Ten years of ozonesonde measurements at the south pole: Implications for recovery of springtime Antarctic ozone, J. Geophys. Res.

Relationship to *Ozone Depleting Gas Index* and *Annual Greenhouse Gas Index*

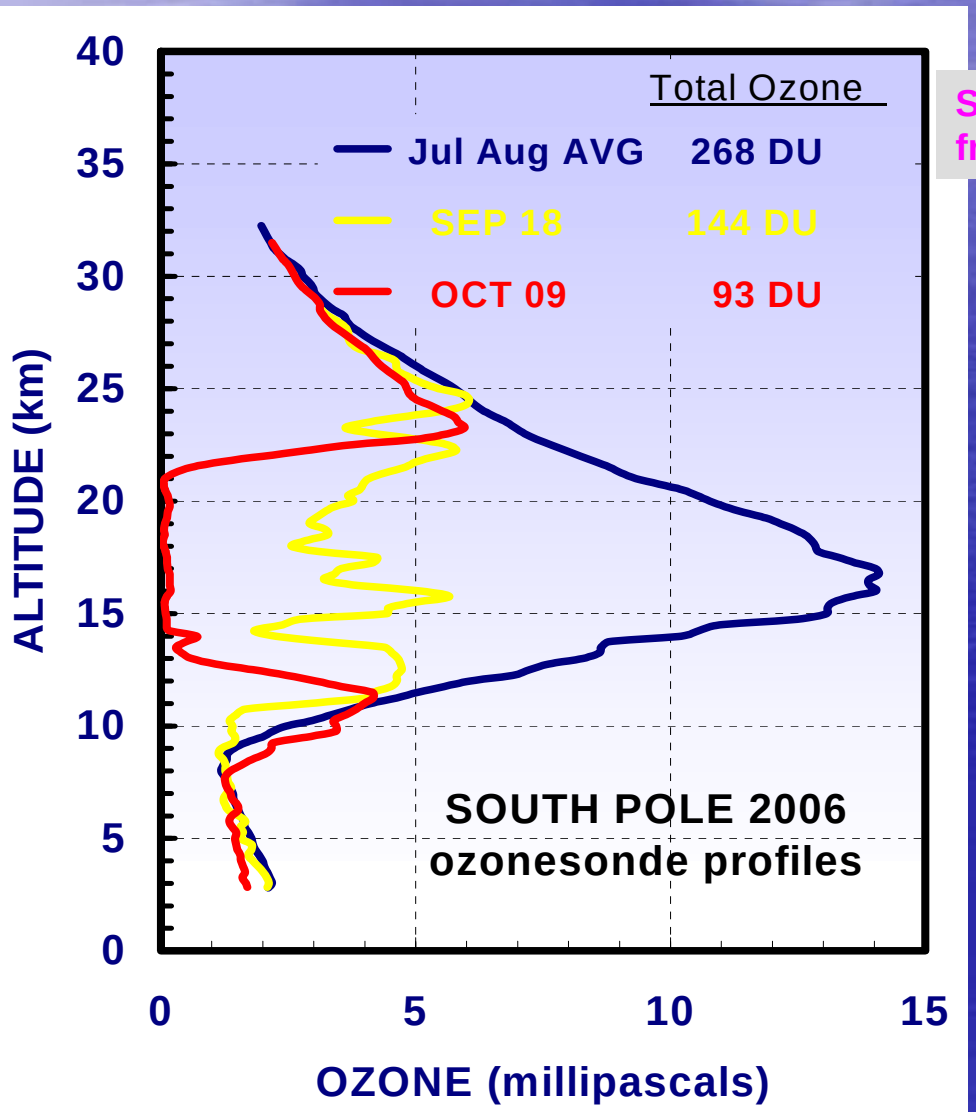




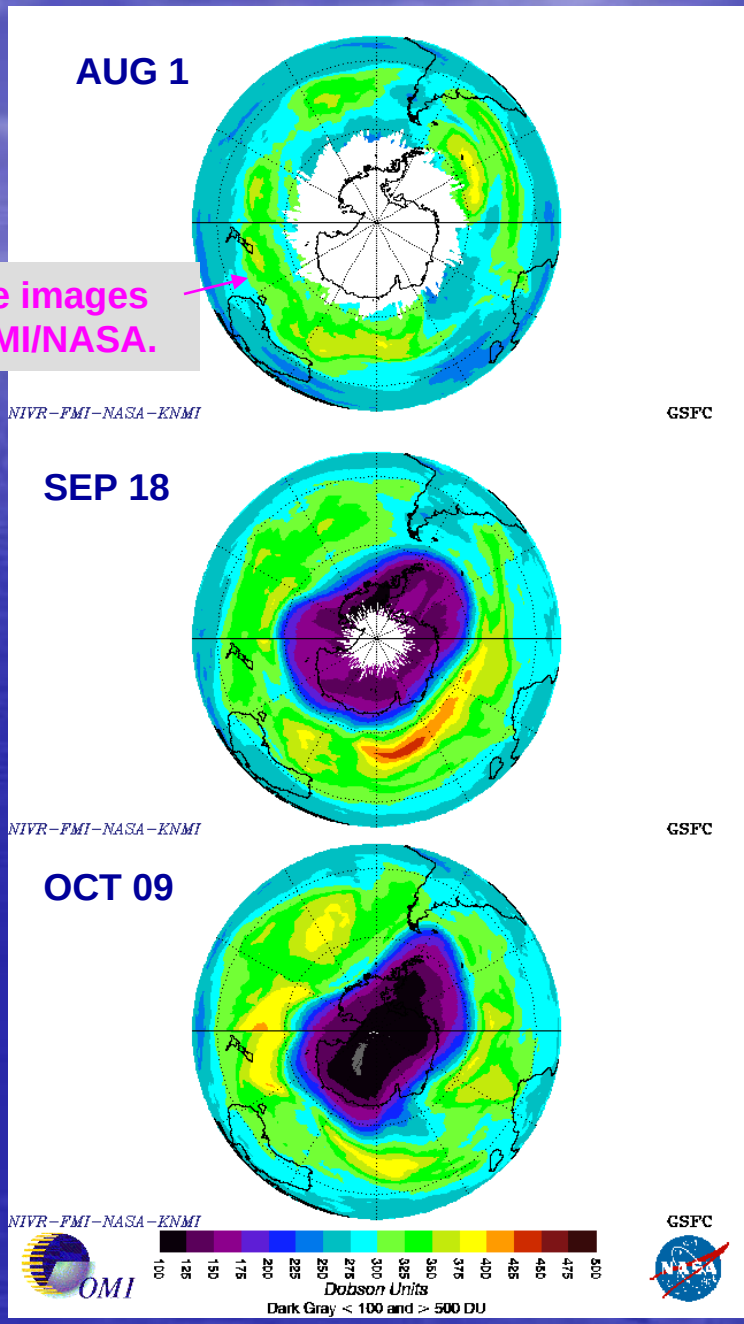


Yearly minimum ozone profile (in red) compared to pre-ozone hole profile from July/August (in blue).

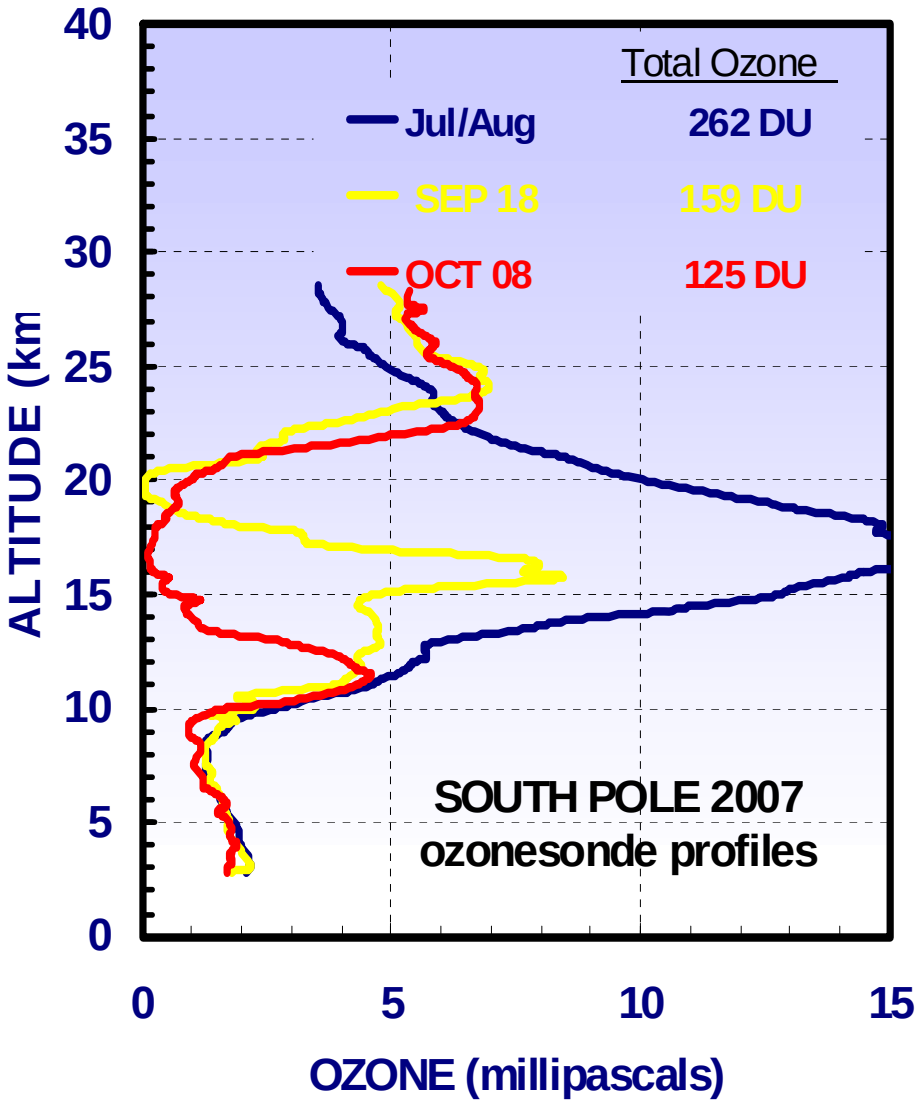
Three selected ozone profiles from 2006 showing the pre-ozone hole (July to mid August) average, mid-September, and the minimum total column ozone profile.



Satellite images from OMI/NASA.

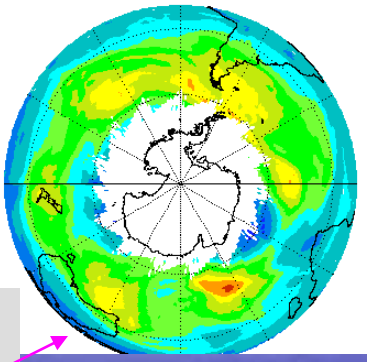


Three selected ozone profiles from 2007 showing the pre-ozone hole (July to mid August) average, mid-September, and the minimum total column ozone profile.

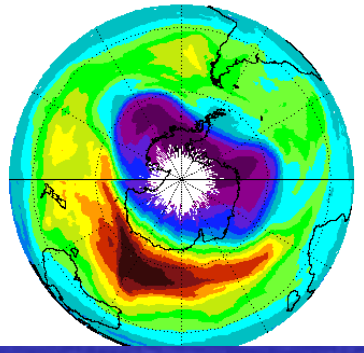


Satellite images from OMI/NASA.

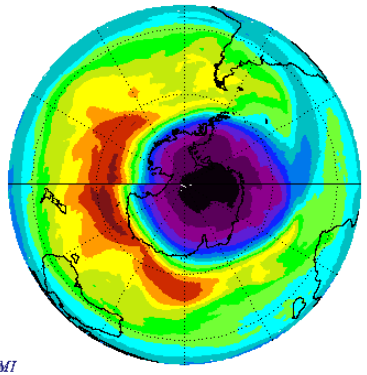
AUG 1



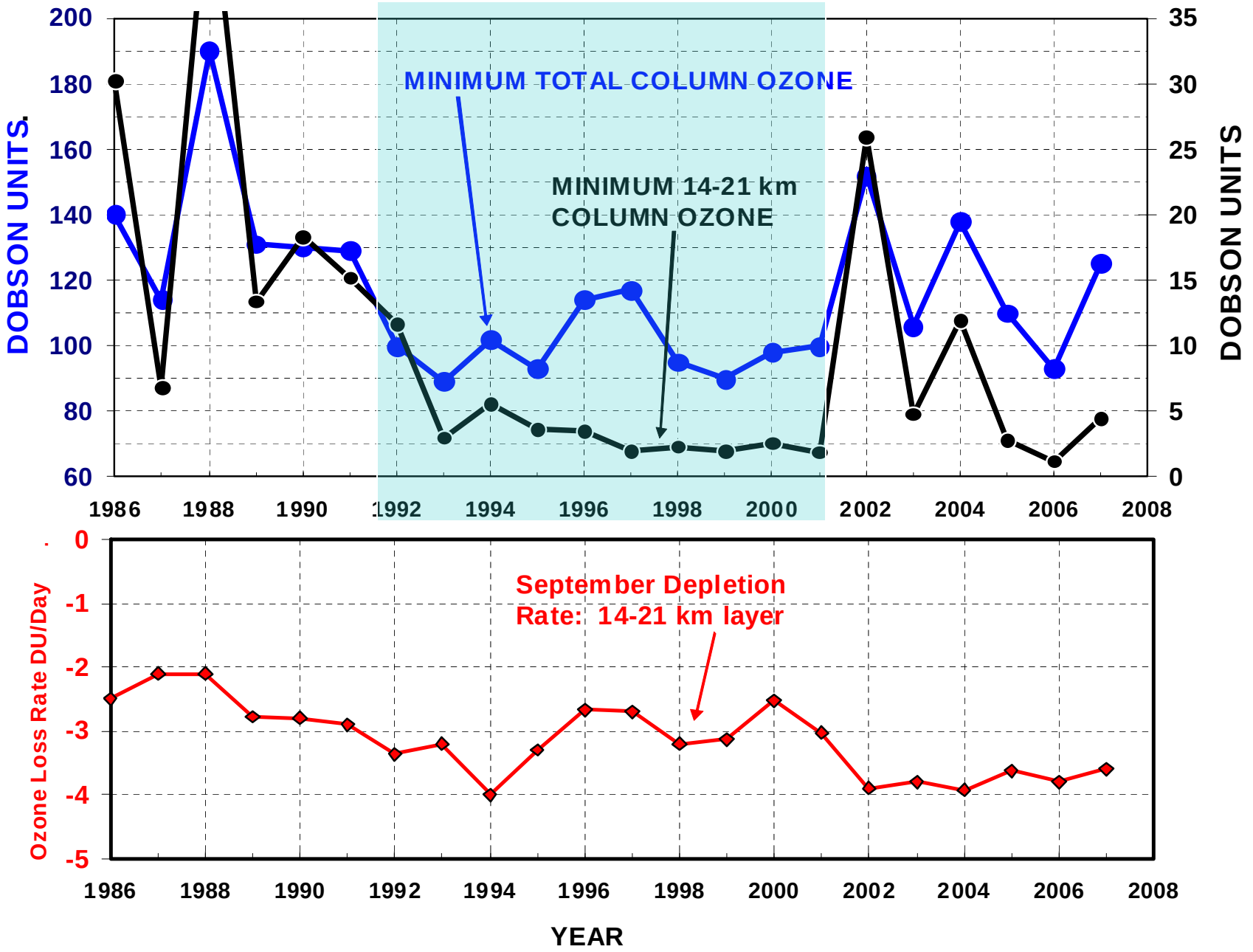
SEP 18



OCT 08

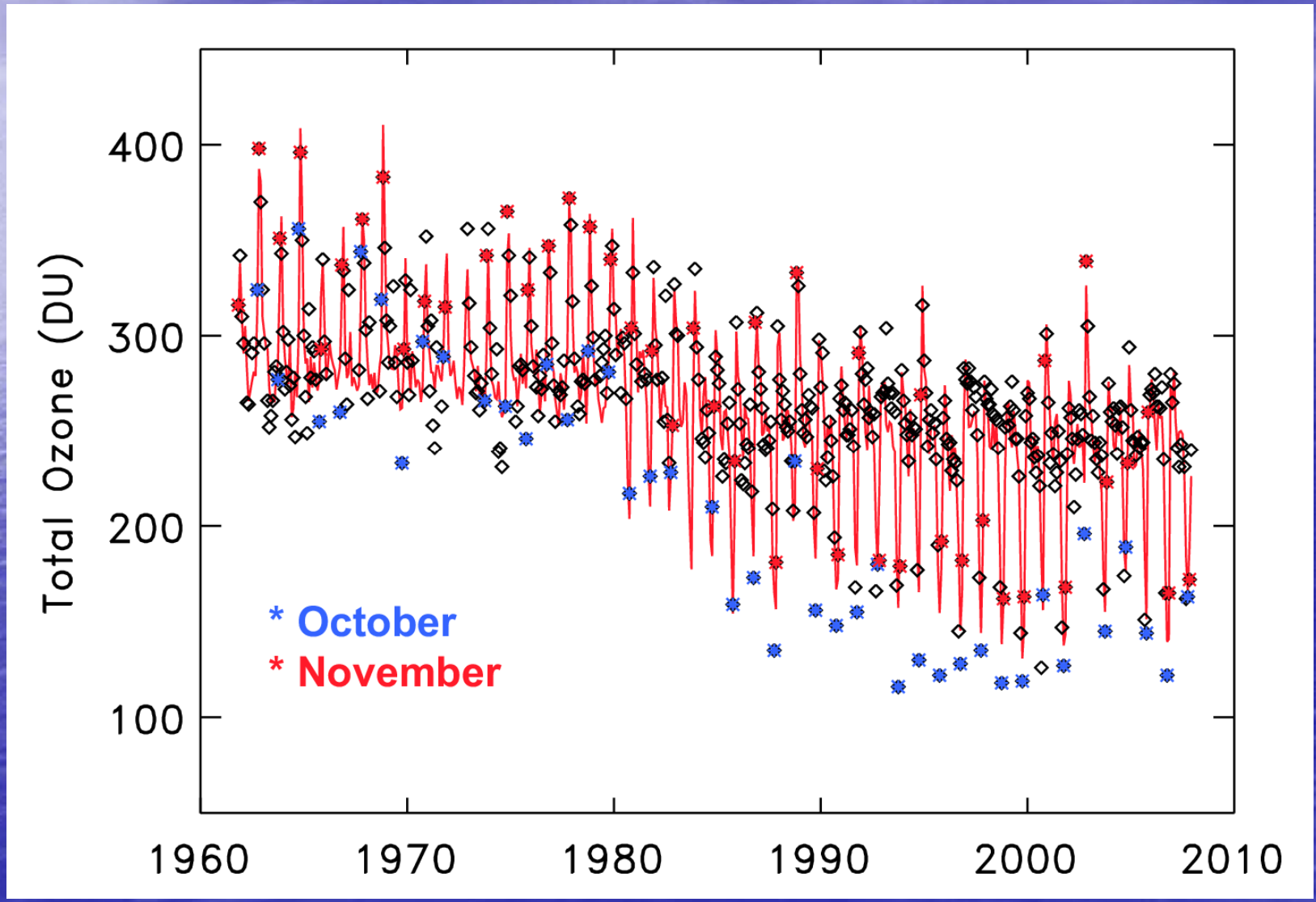


The lowest column ozone measured by ozonesondes at South Pole station each year since 1986



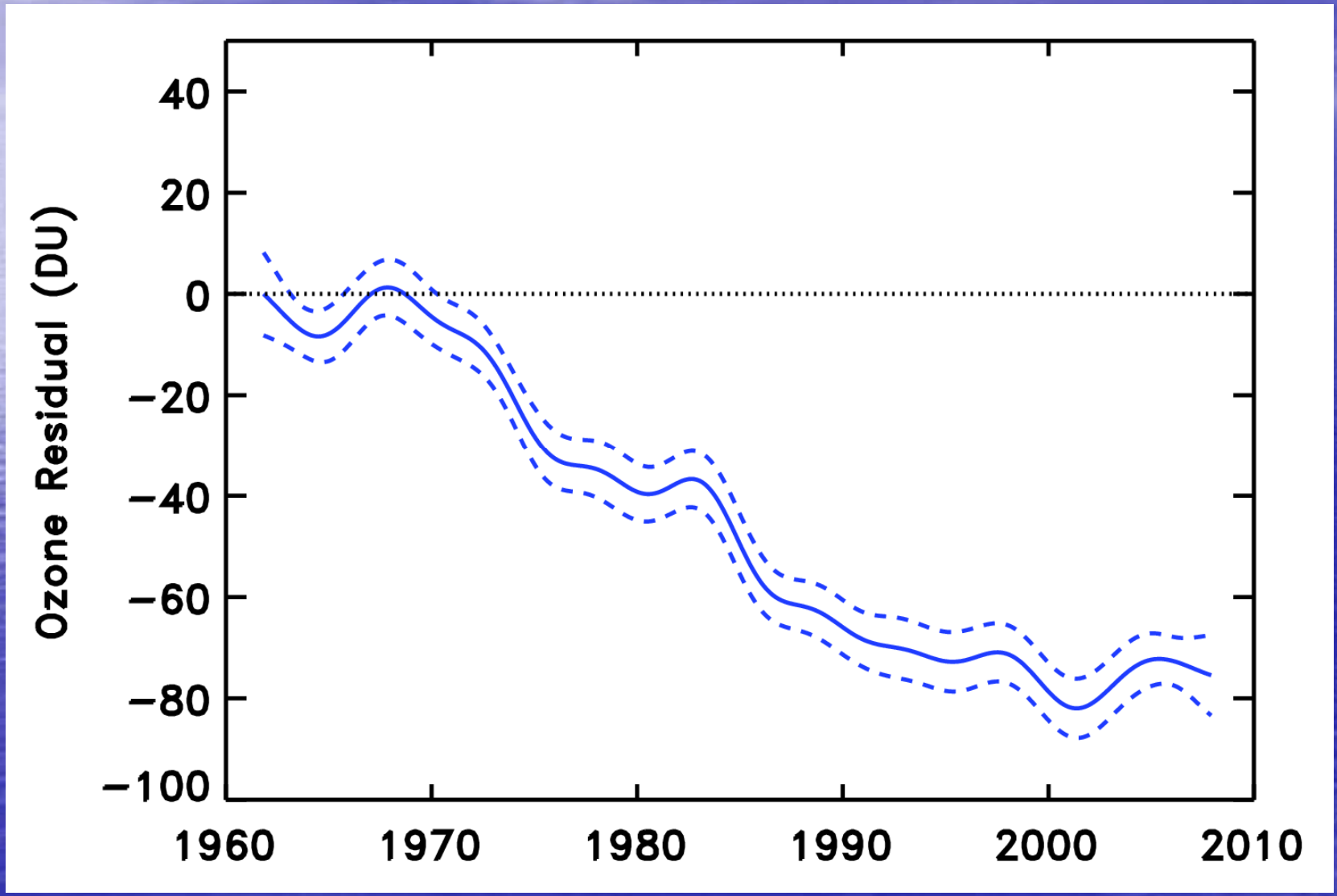
South Pole
Total Column Ozone (1962-2007)

Diamonds – monthly means
Red solid – model fit



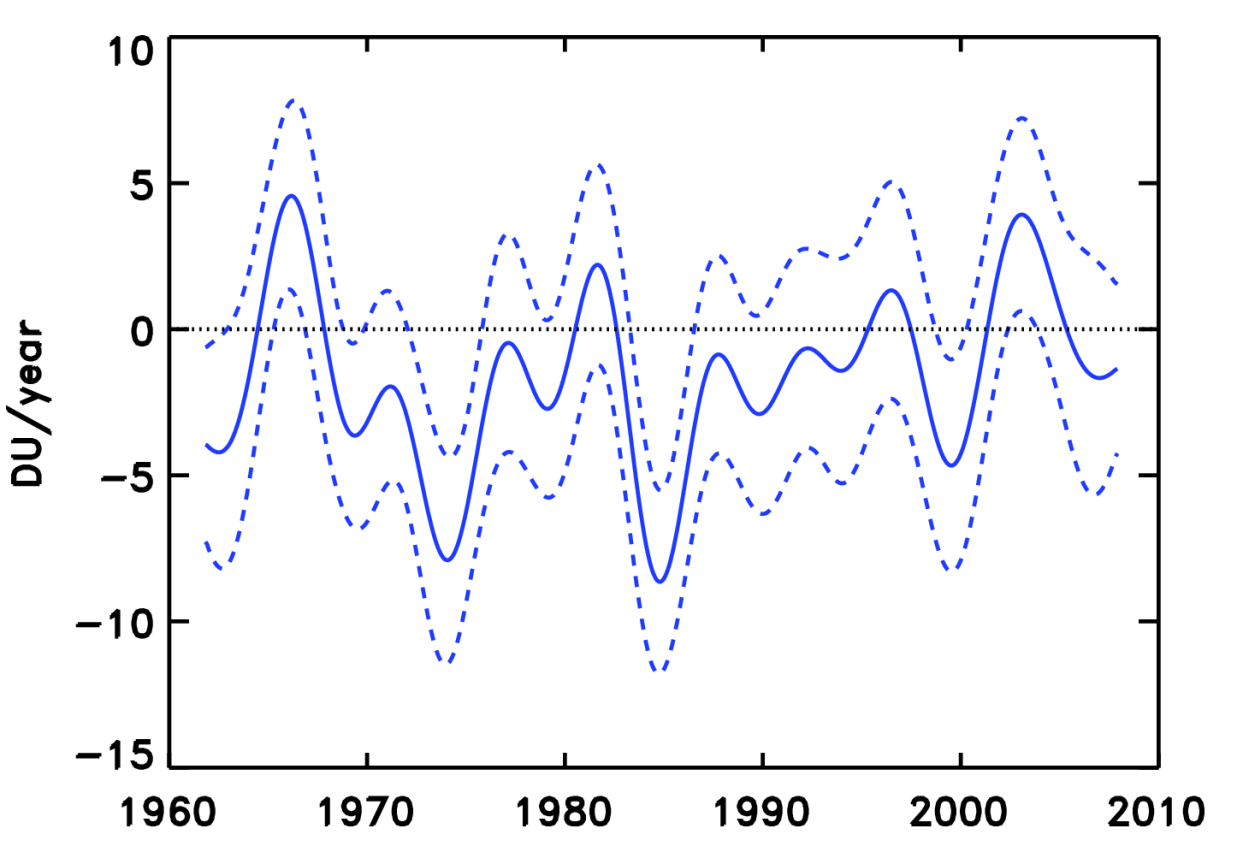
South Pole Total Column Ozone

Tendency curve (smoothed residuals plus polynomial)
±2 standard deviations from 100 realizations applied to residuals



South Pole Total Column Ozone

Instantaneous growth rate curve found from differentiating the tendency curve.



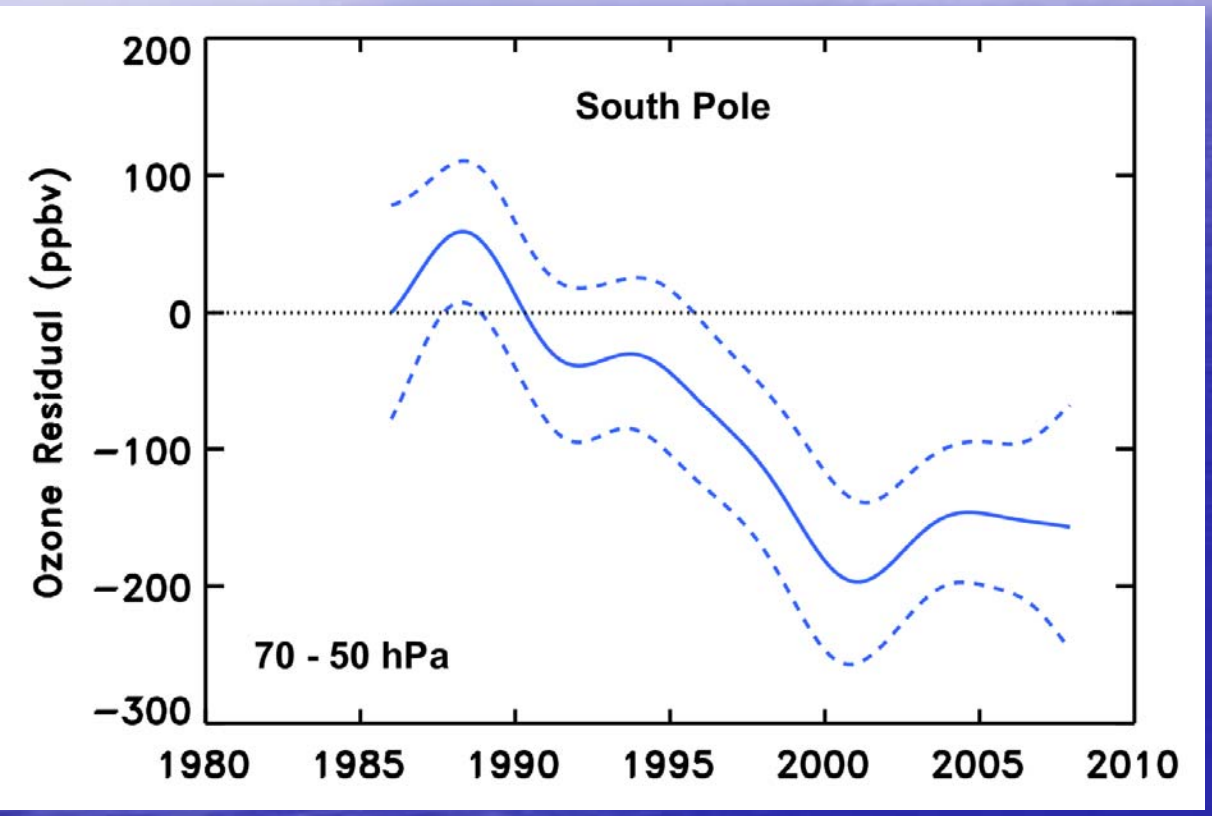
Average growth rate 1962-2007: -6.27 ± 0.15 % / dec

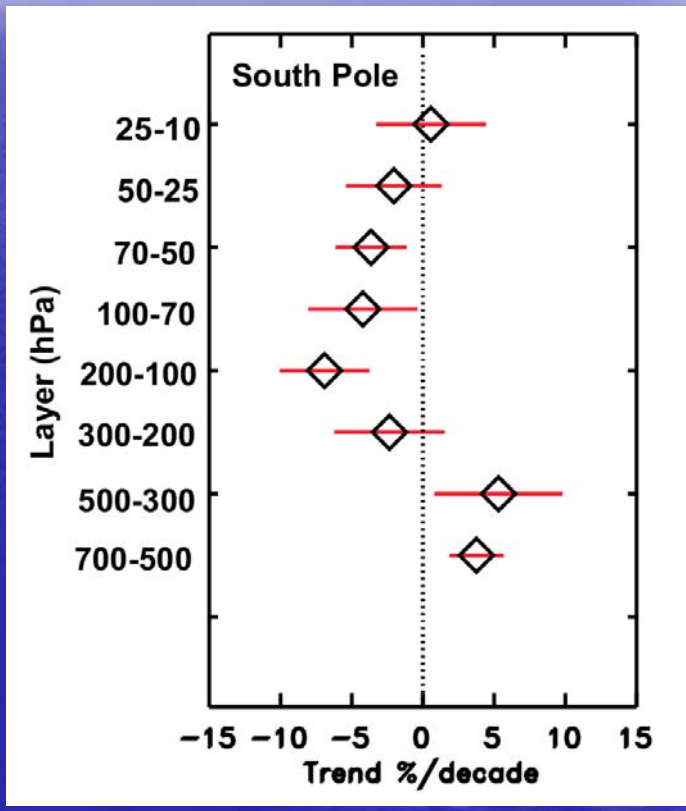
Average growth rate 1968-1995: -11.1 % / decade

Average growth rate 1996-2007: -1.38 % / decade

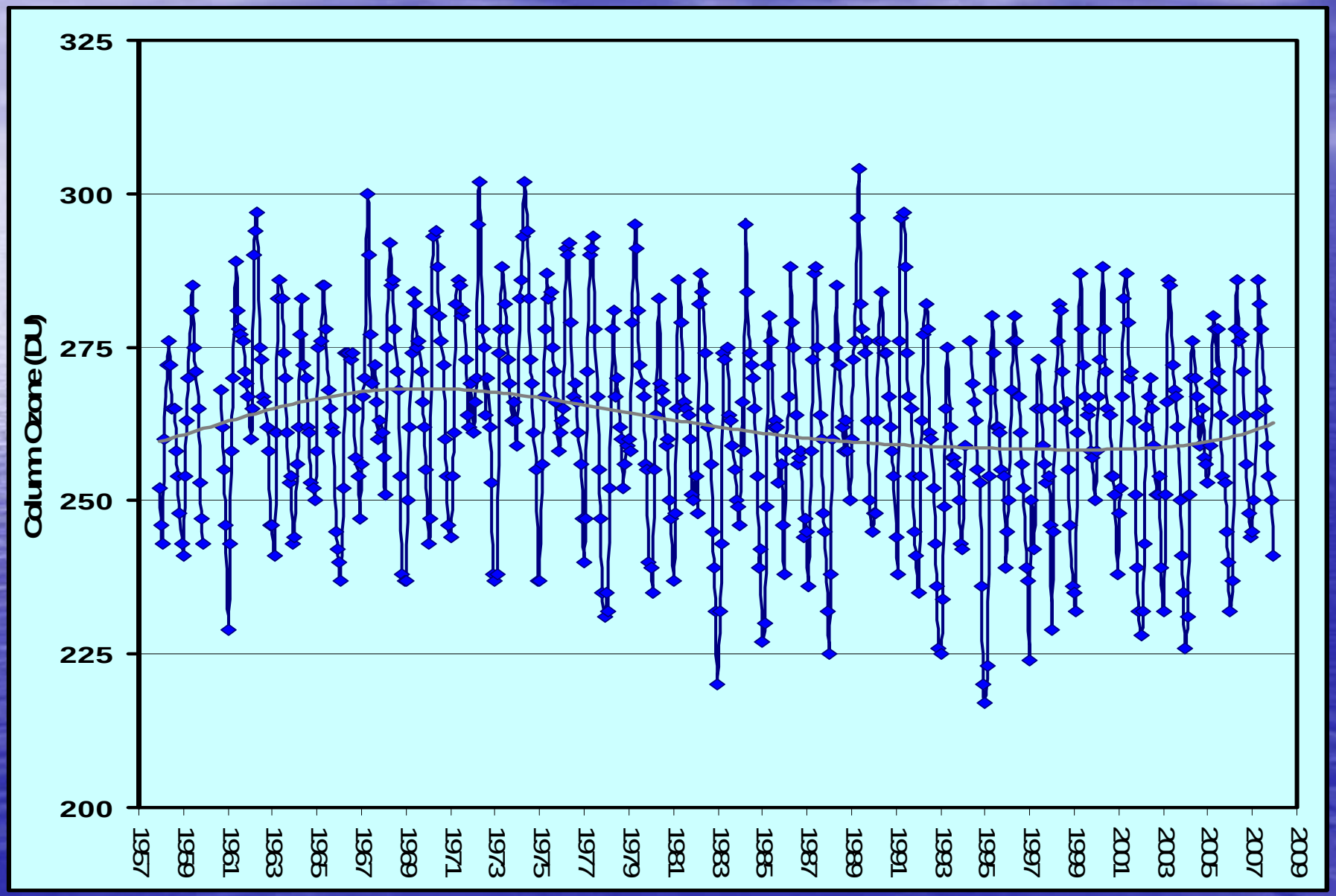
South Pole Layer Trend for 70 - 50 hPa and Trend with Altitude

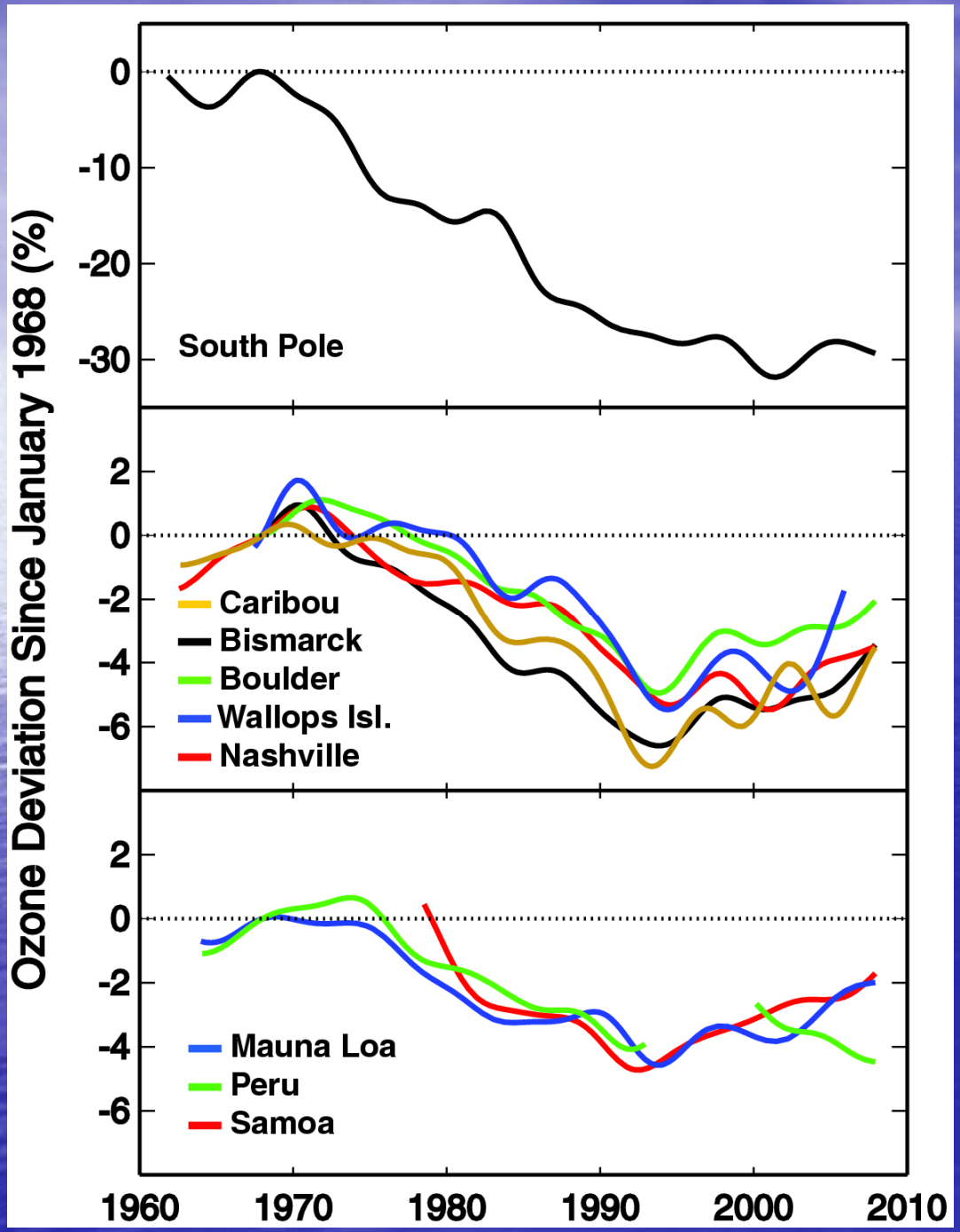
Tendency curve (smoothed residuals plus polynomial)
±2 standard deviations from 100 realizations applied to residuals





Mauna Loa Total Column Ozone (1958-2007)

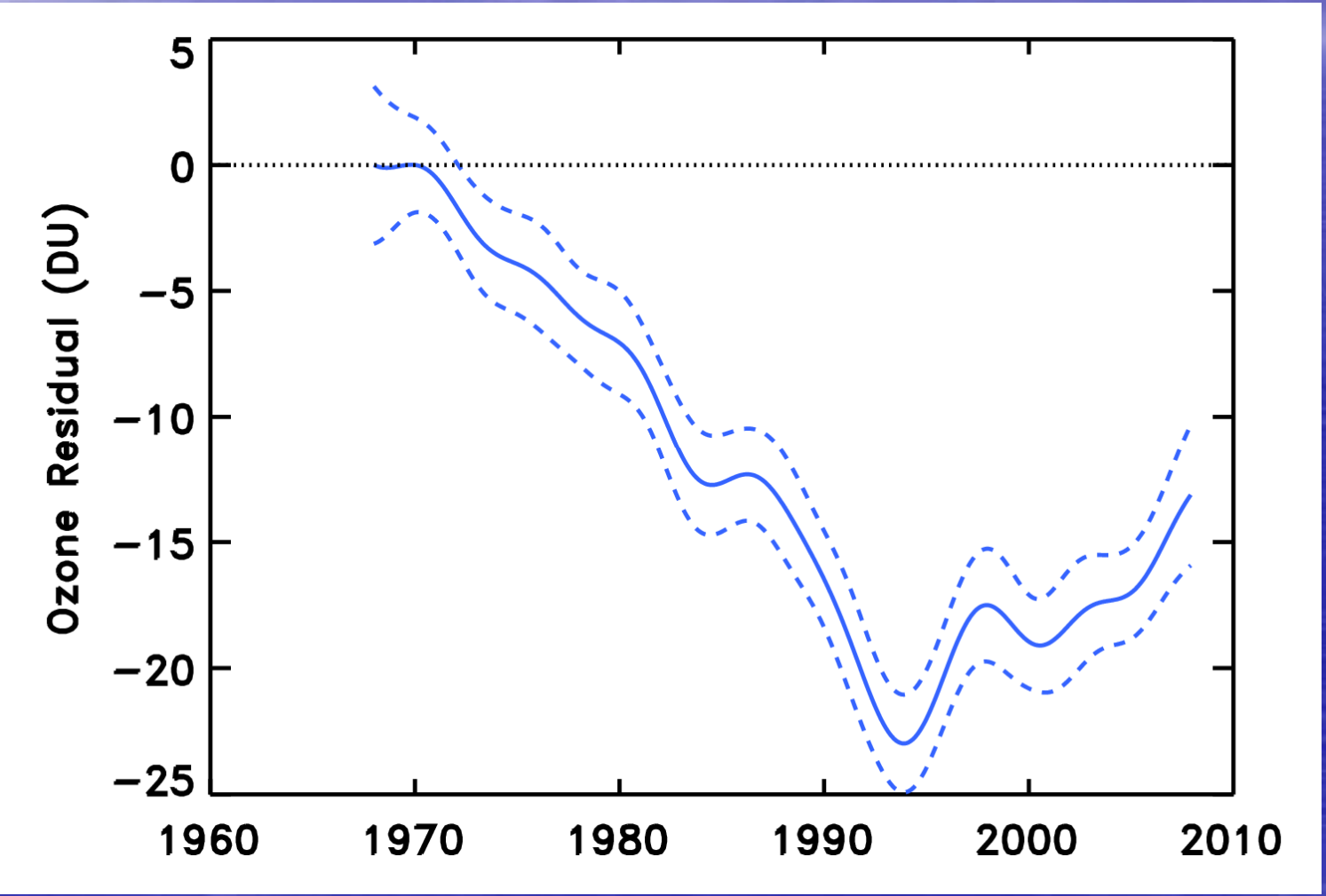




Smooth trend curves of monthly ozone values from selected Dobson stations (South Pole, continental US, and the tropics). Changes represented by the growth rate determined from these may be a measure of the rate of change of stratospheric ozone and thus represent various aspects of ozone layer recovery.

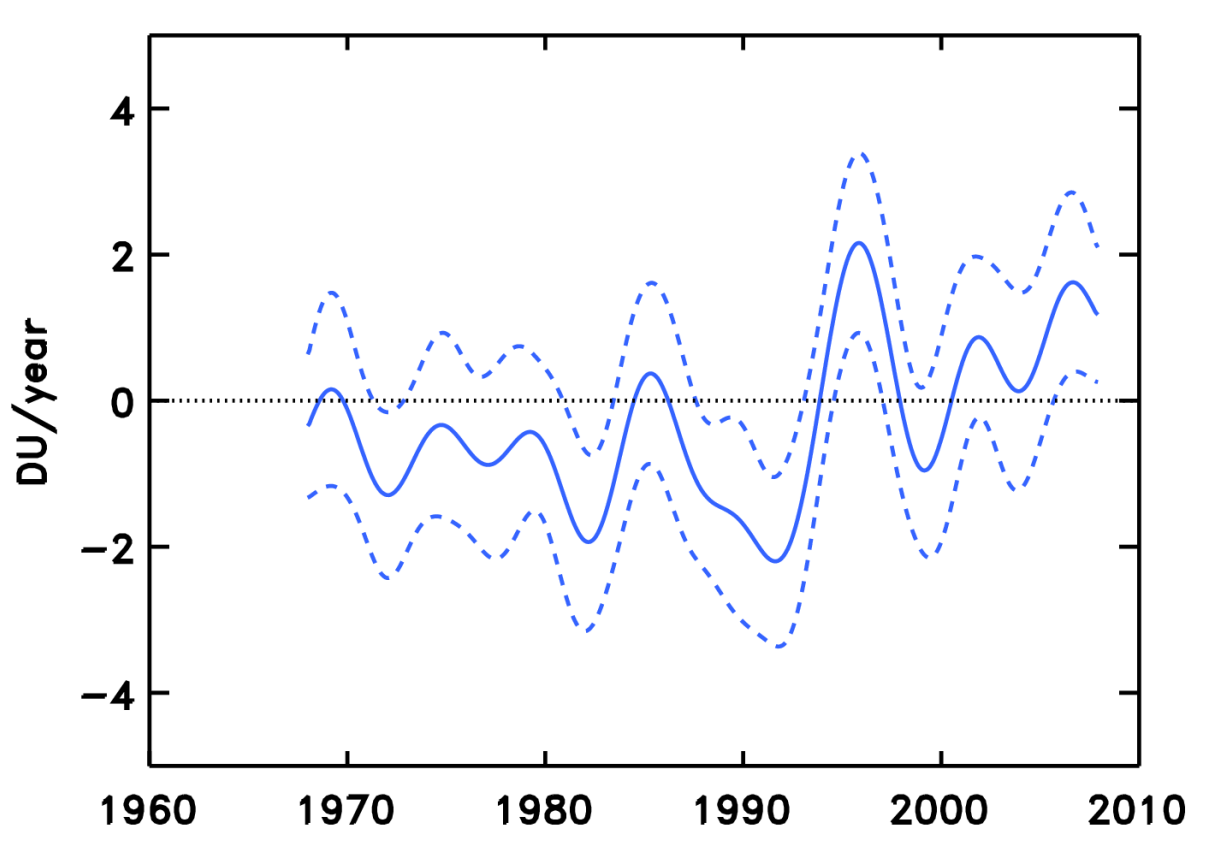
Continental U.S. Total Column Ozone

Tendency curve (smoothed residuals plus polynomial)
±2 standard deviations from 100 realizations applied to residuals



Continental U.S. Total Column Ozone

Instantaneous growth rate curve found from differentiating the tendency curve.



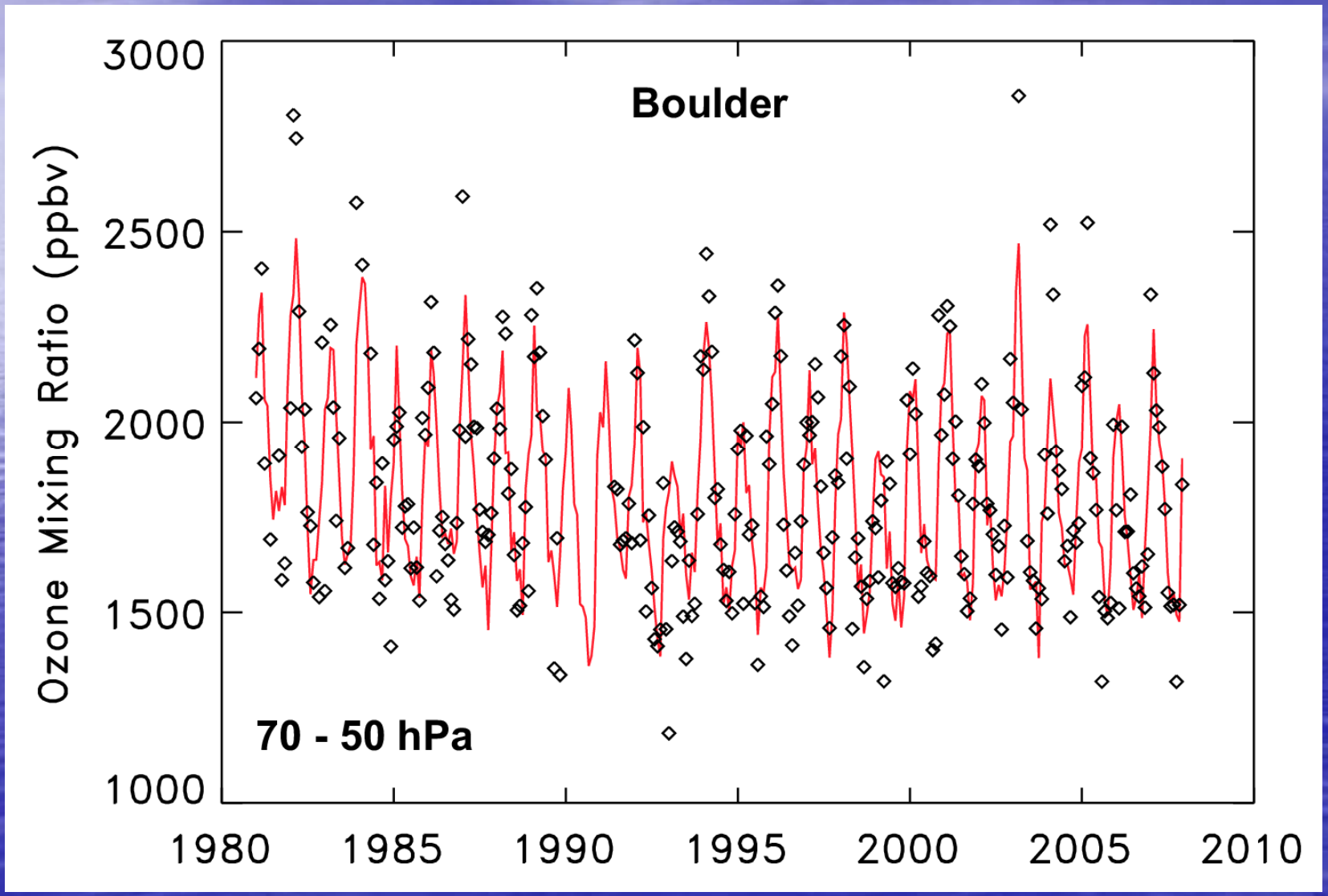
Average growth rate 1968-2007: -1.01 ± 0.15 % / dec

Average growth rate 1968-1995: -2.16 % / decade

Average growth rate 1996-2007: +1.73 % / decade

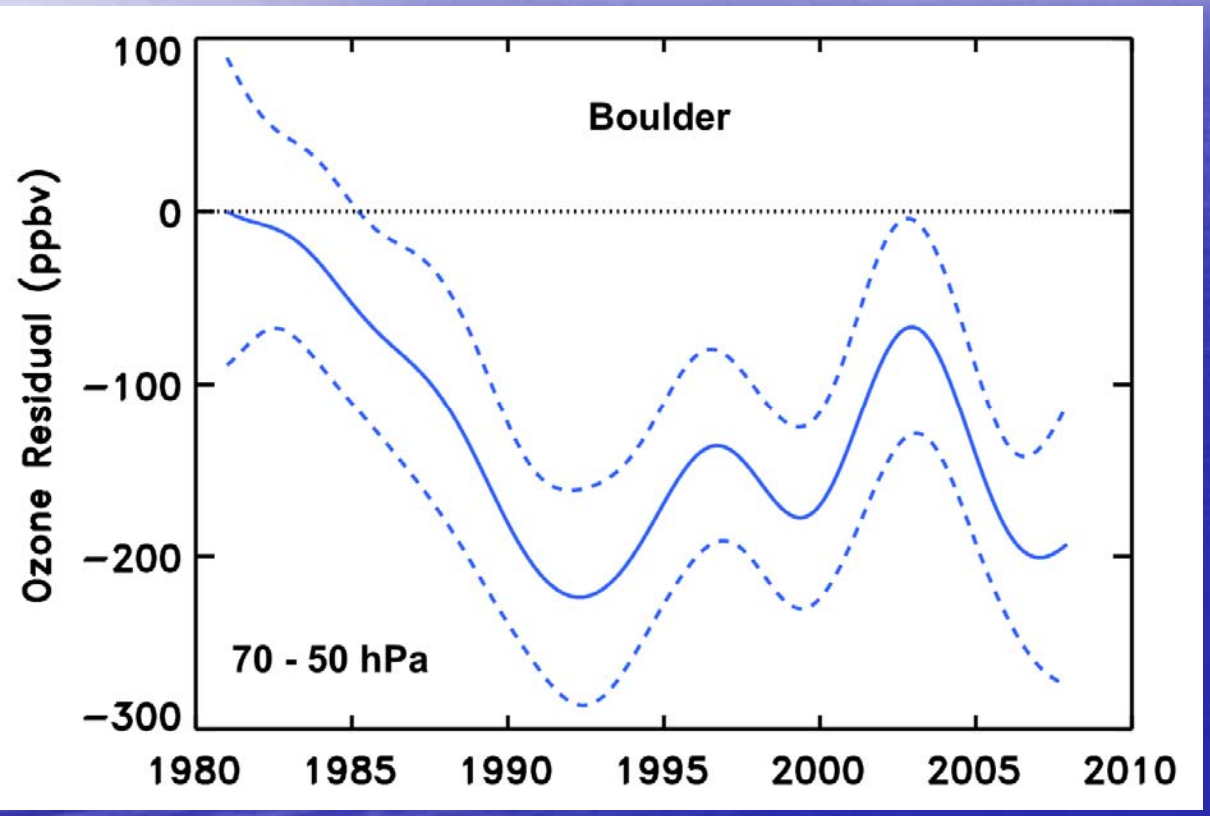
Boulder Layer Average for 70 – 50 hPa

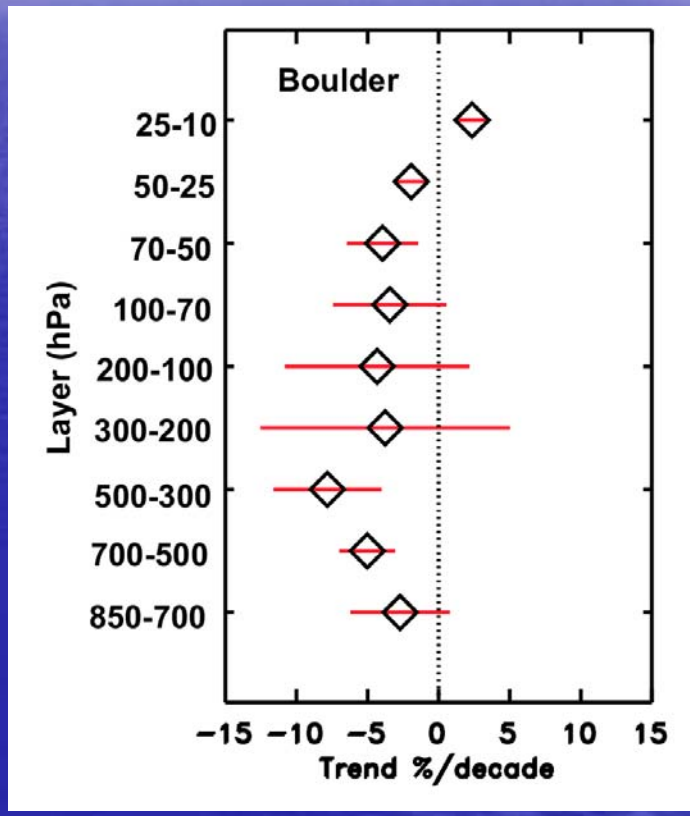
Diamonds – monthly means
Red solid – model fit



Boulder Layer Trend for 70 - 50 hPa and Trend with Altitude

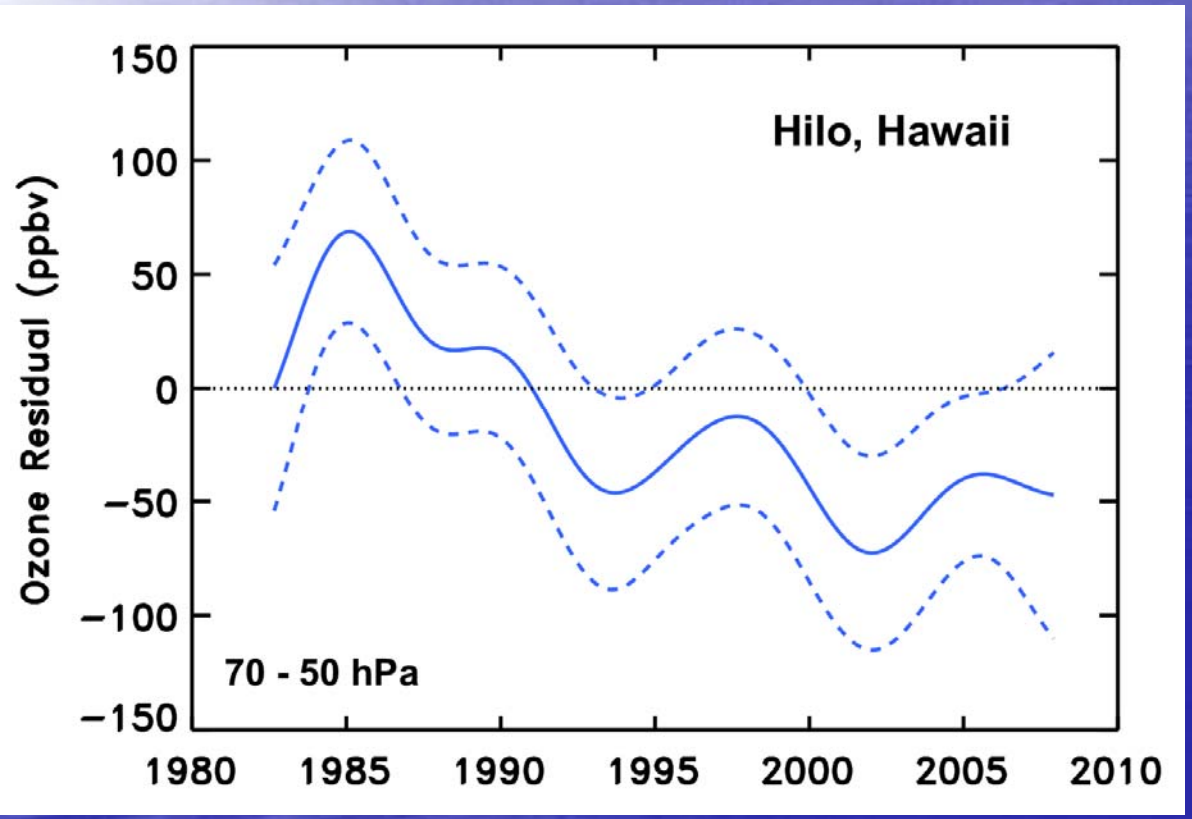
Tendency curve (smoothed residuals plus polynomial)
±2 standard deviations from 100 realizations applied to residuals

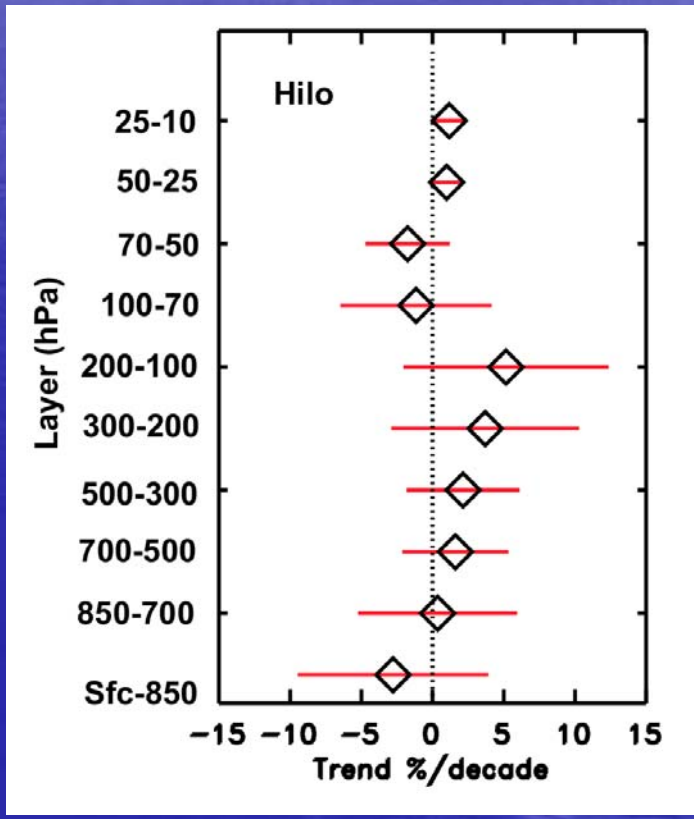




Hilo, Hawaii Layer Trend for 70 - 50 hPa and Trend with Altitude

Tendency curve (smoothed residuals plus polynomial)
±2 standard deviations from 100 realizations applied to residuals



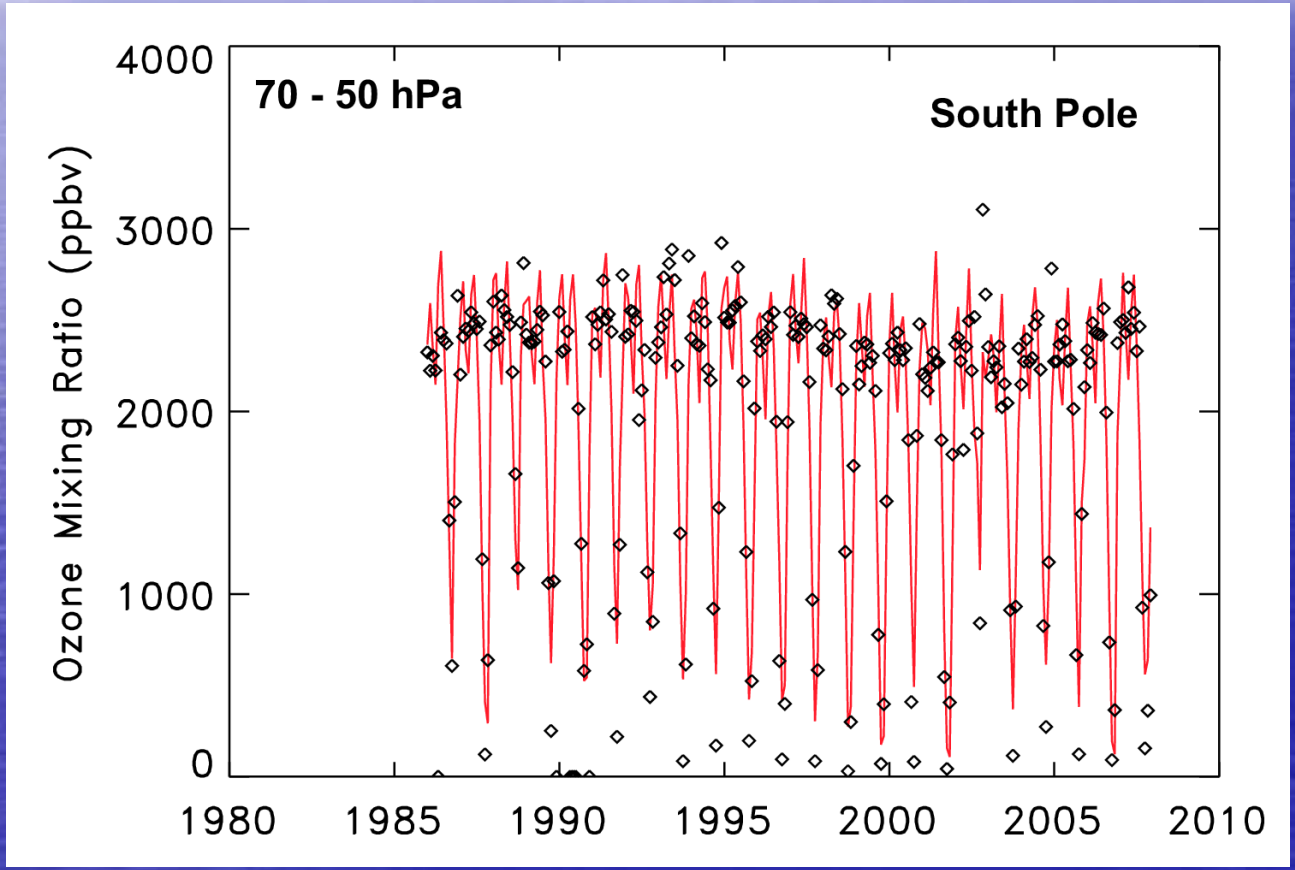


Conclusions

- Dave Hofmann's ground breaking research on stratospheric ozone changes continues to lead the way in tracking ozone recovery.
- South Pole ozone does not show definite signs of recovery and is not expected to for a number of years.
- Mid latitude stratospheric ozone my show early signs of recovery.

South Pole Layer Average for 70 – 50 hPa

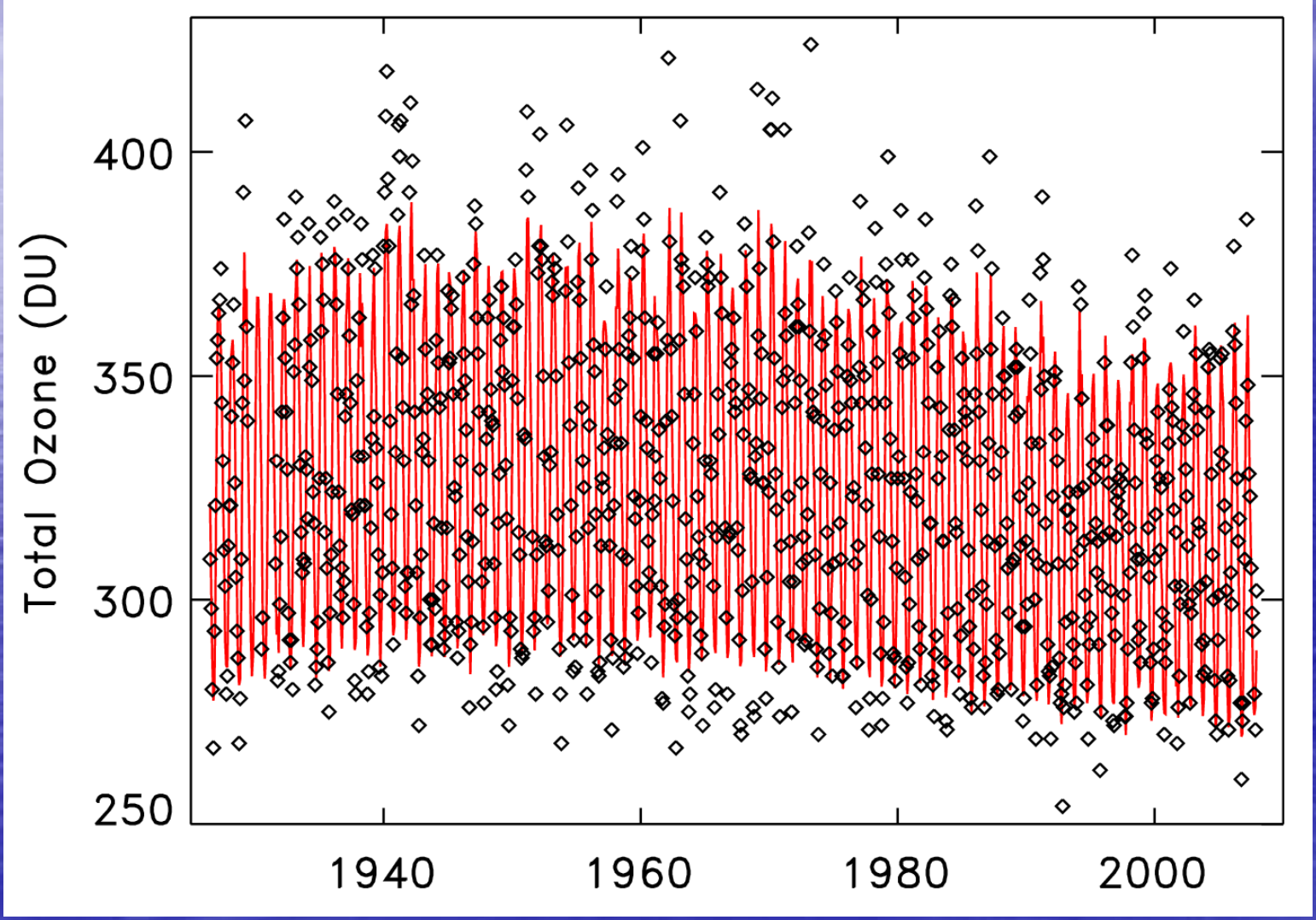
Diamonds – monthly means
Red solid – model fit



Arosa, Switzerland
Total Column Ozone (1926-2007)

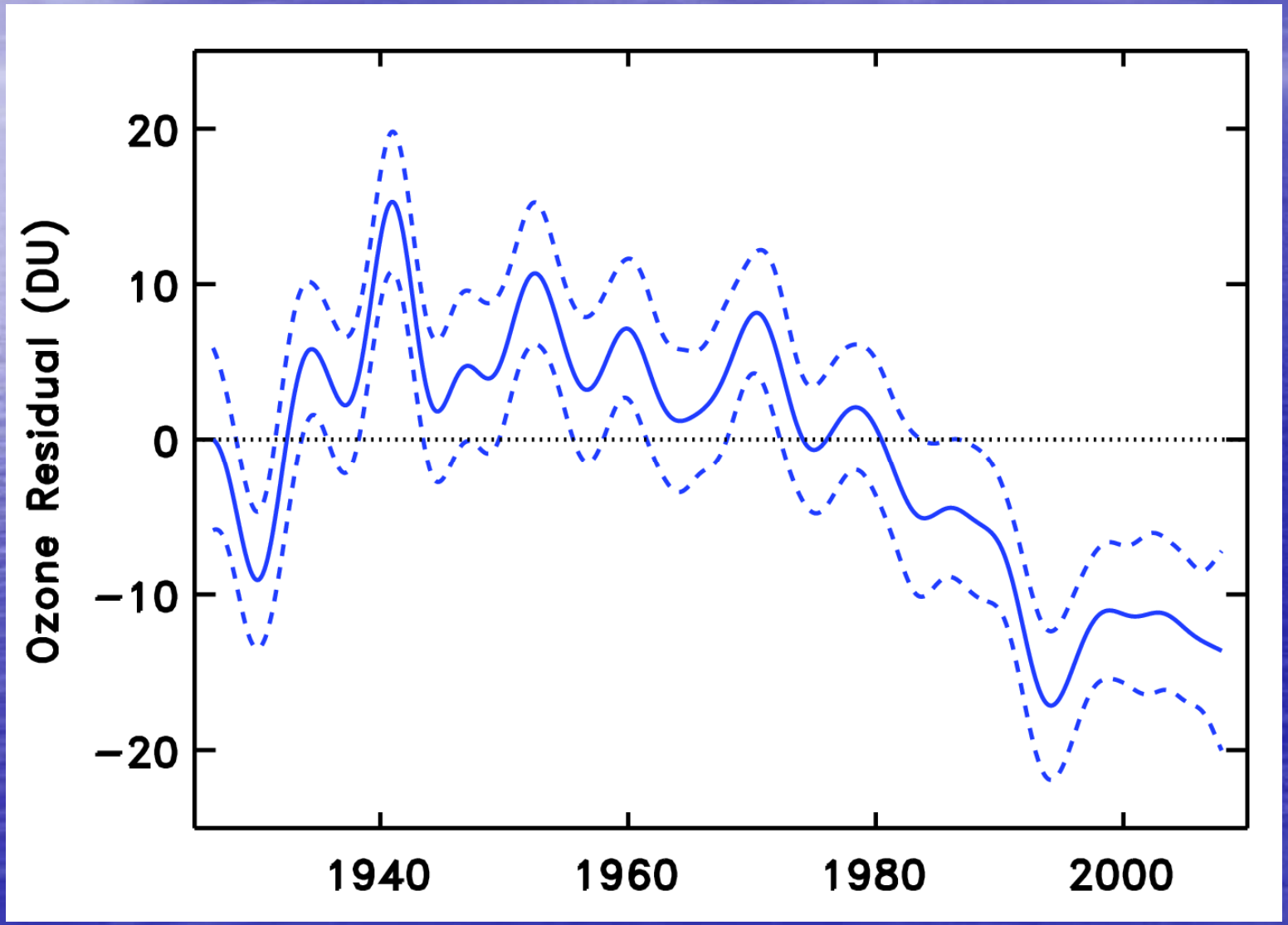
Diamonds – monthly means

Red solid – model fit (seasonal, solar, and cubic polynomial only)



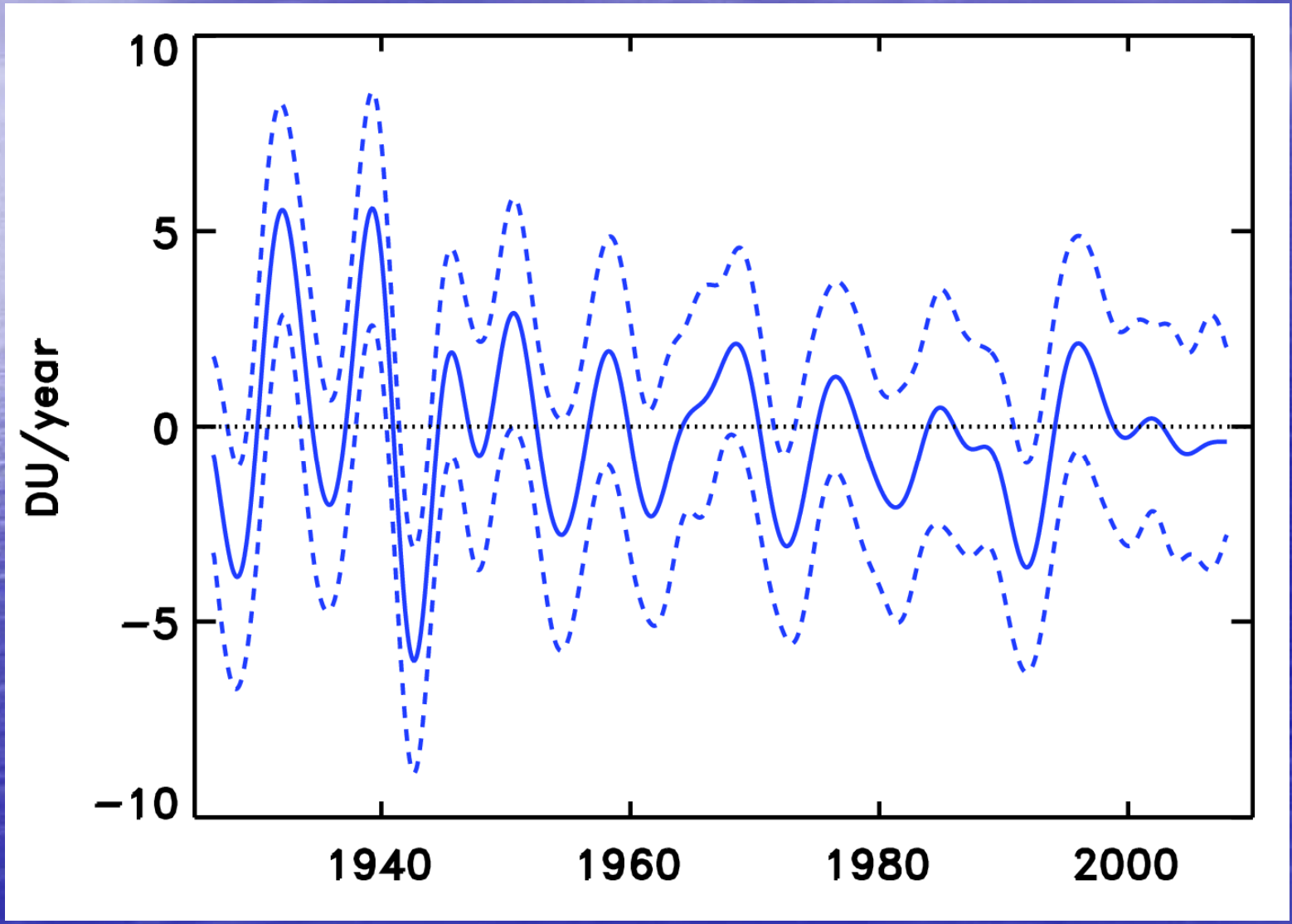
Arosa, Switzerland Total Column Ozone

Tendency curve (smoothed residuals plus polynomial)
±2 standard deviations from 100 realizations applied to residuals



Arosa, Switzerland Total Column Ozone

Instantaneous growth rate curve found from differentiating the tendency curve.



Mauna Loa Total Column Ozone

Tendency curve (smoothed residuals plus polynomial)
±2 standard deviations from 100 realizations applied to residuals