The Search for Ozone Recovery Using 36 Years of SBUV Satellite Data

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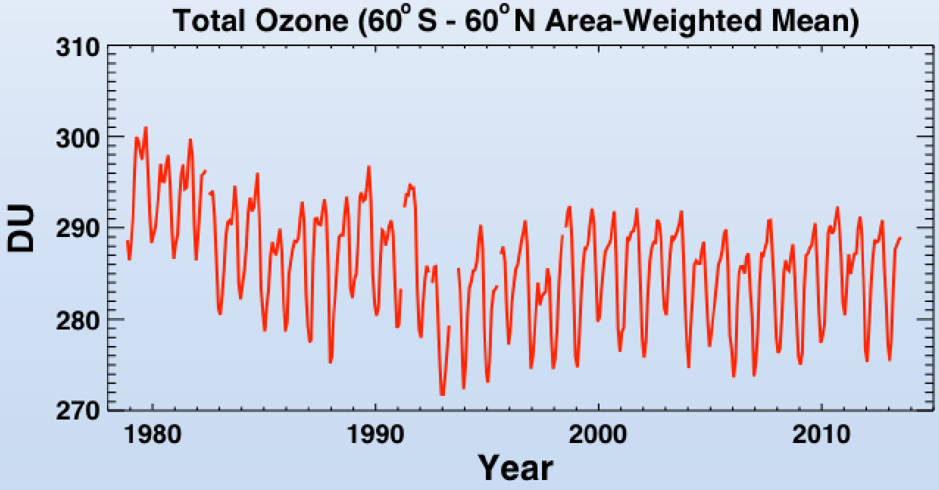

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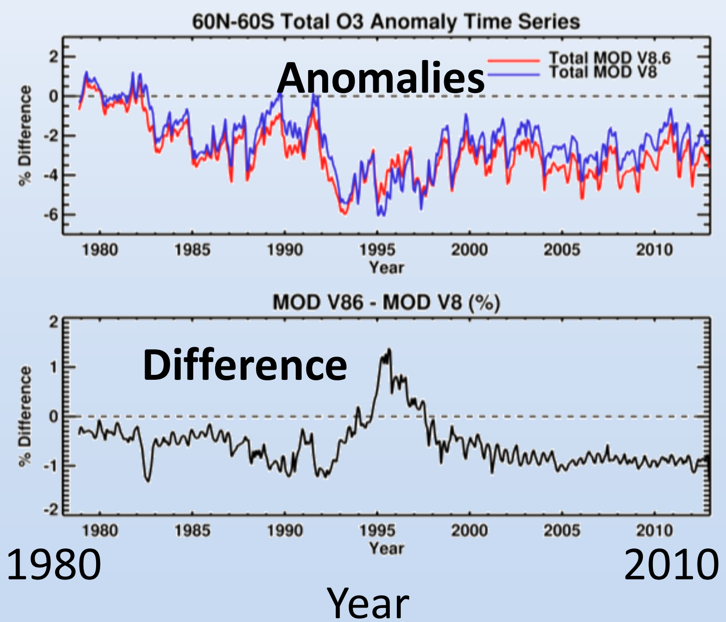
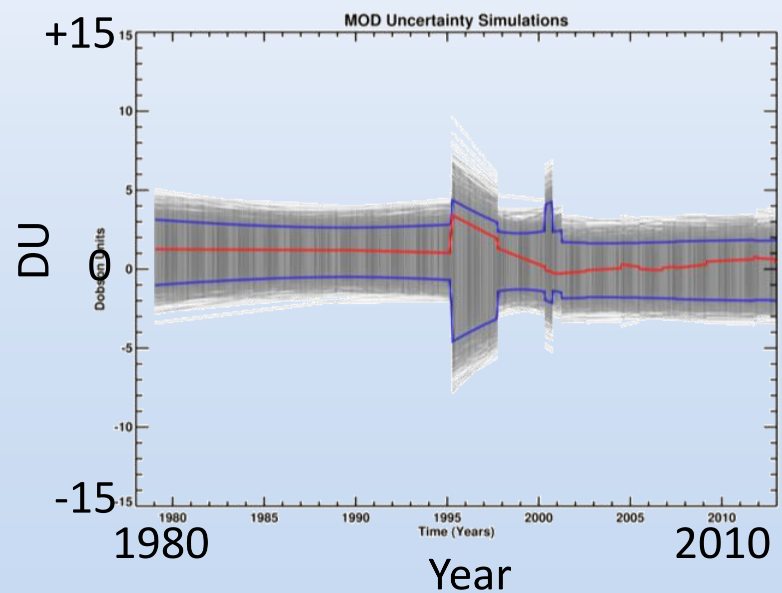
SBUV (Solar Backscatter UltraViolet) Instruments

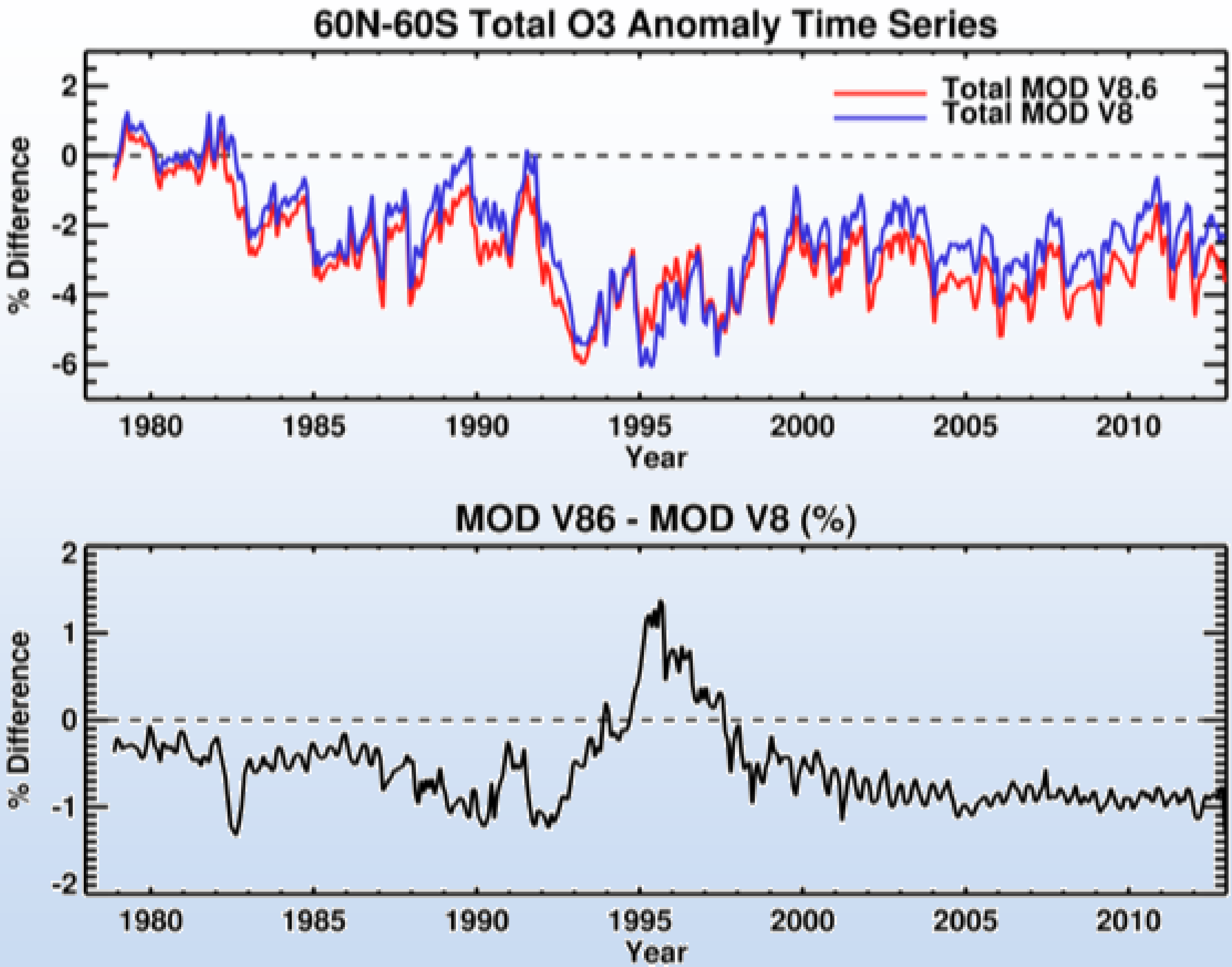
- **Nadir-viewing; use solar UV radiation backscattered from the atmosphere to measure ozone**
- **New Version 8.6 (replacing version 8)**
  - **Total ozone is the sum of layer amounts**
  - **Early instrument calibration to SSBUV; late instrument calibration to NOAA 17**
- **Merged ozone data set (MOD) SBUV only: no TOMS data**

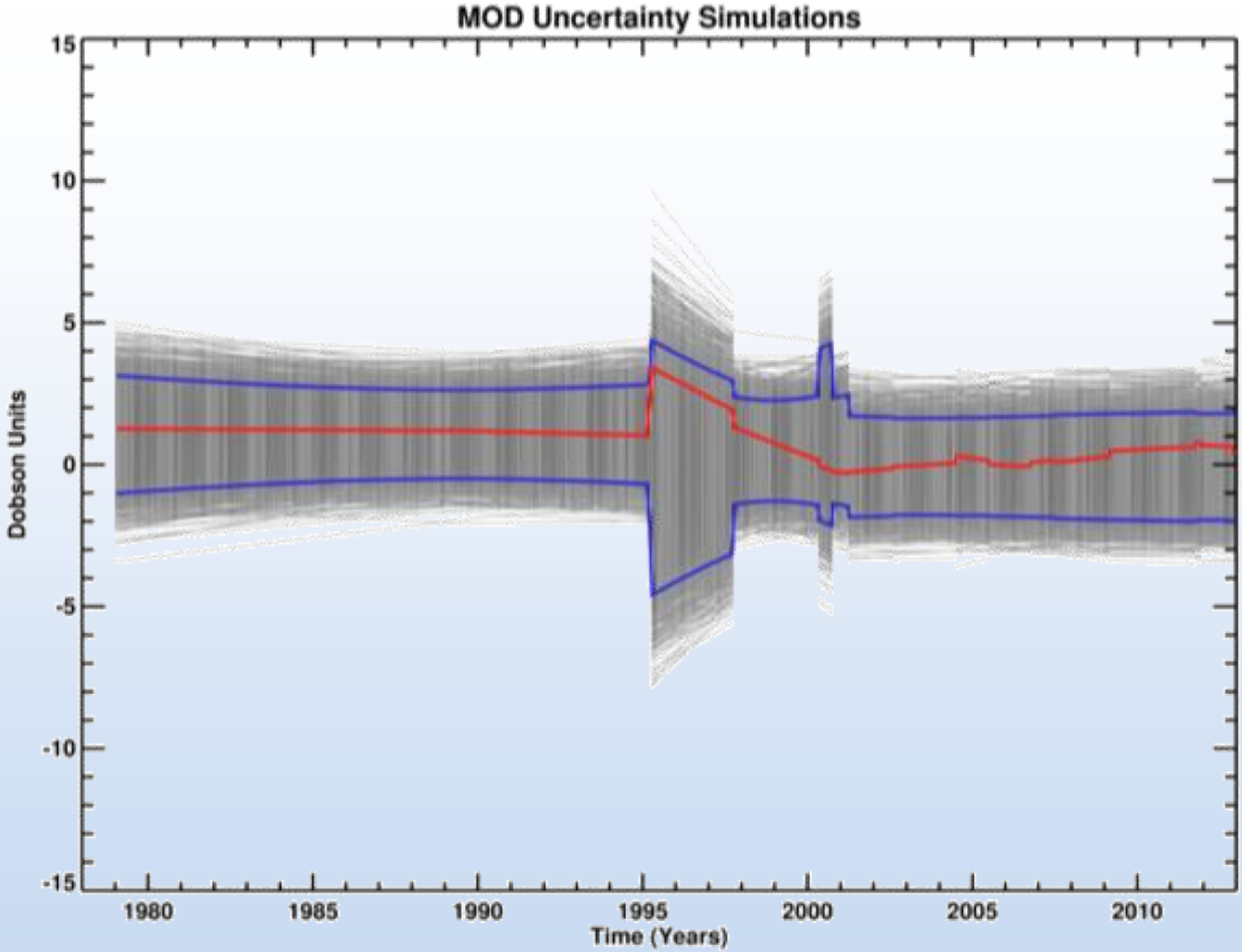
Version 8.6 to 8



Merging Uncertainty




60N-60S Total O3 Anomaly Time Series
Total MOD V8.6
Total MOD V8
% Difference
Year
MOD V86 - MOD V8 (%)
% Difference
Year

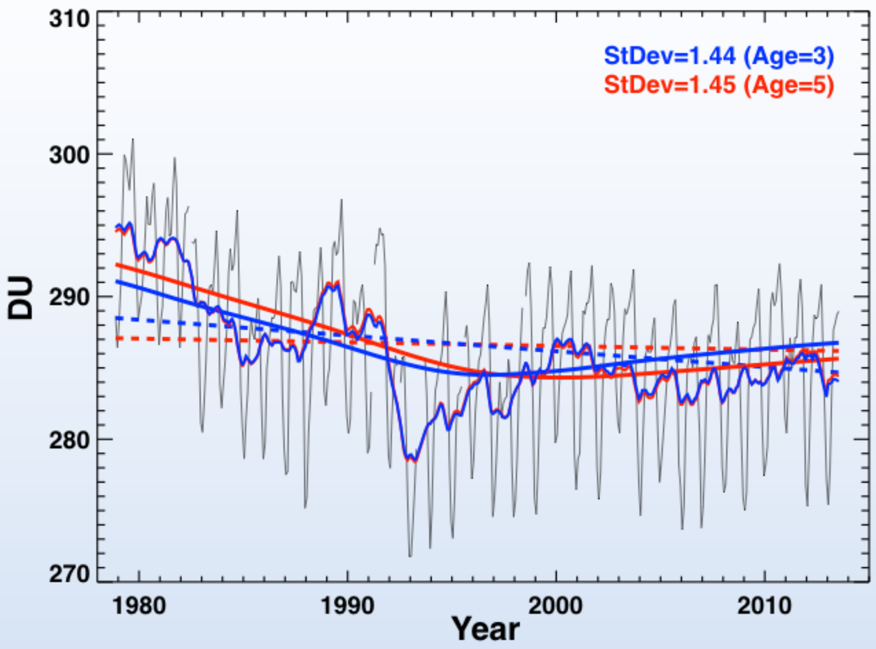

MOD Uncertainty Simulations
Dobson Units
Time (Years)
15
10
5
0
-5
-10
-15
1980
1985
1990
1995
2000
2005
2010

Can we separate ozone change due to ODSs from that due to GHGs?

Example: 60S-60N Total Column Ozone: Fit to EESC + Linear Trend (plus Solar, volcanos, QBO, and ENSO)

Use Nash/Newman EESC (2 examples; Age=3 years and Age=5 years)

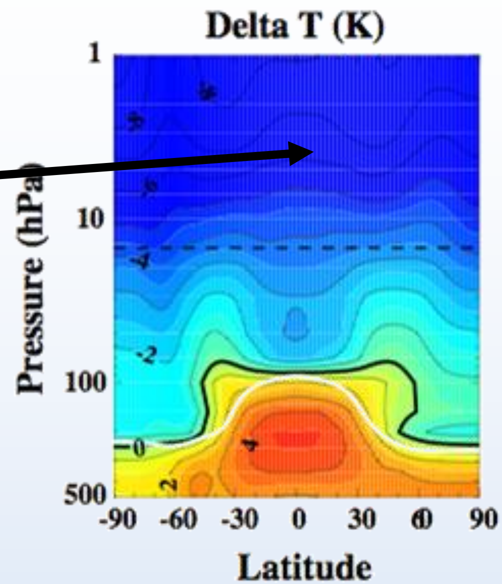
Linear trend represents GHGs and is expected to have a positive coefficient

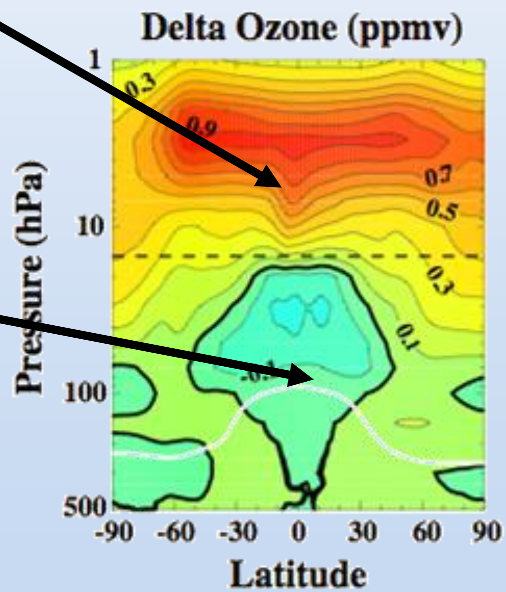


	EESC trend pre-1993	EESC trend post-2000	Linear trend
Age = 3 years	- 4.5 ± 1 DU/dec	+ 1.3 ± 0.3 DU/dec	- 1.1 ± 0.5 DU/dec
Age = 5 years	- 4.7 ± 1 DU/dec	+ 1.3 ± 0.3 DU/dec	- 0.2 ± 0.7 DU/dec

The Impact of GHGs on Stratospheric Ozone

- **Greenhouse gases cool the stratosphere**
- **Cooling slows ozone loss in upper stratosphere leading to ozone increase**
- **Lower stratospheric circulation speeds up leading to tropical ozone decrease and mid-latitude ozone increase**

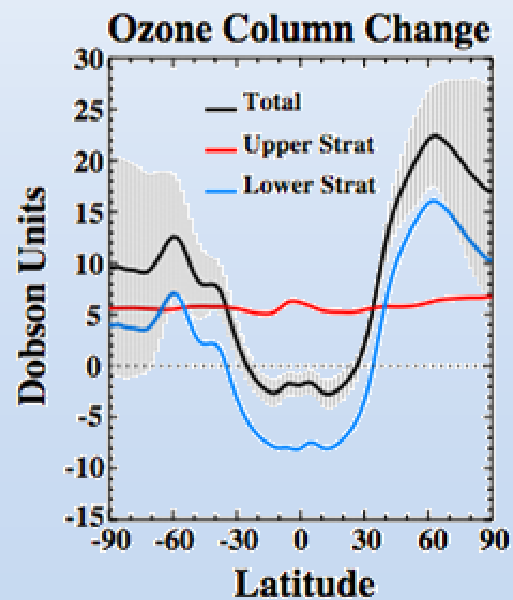




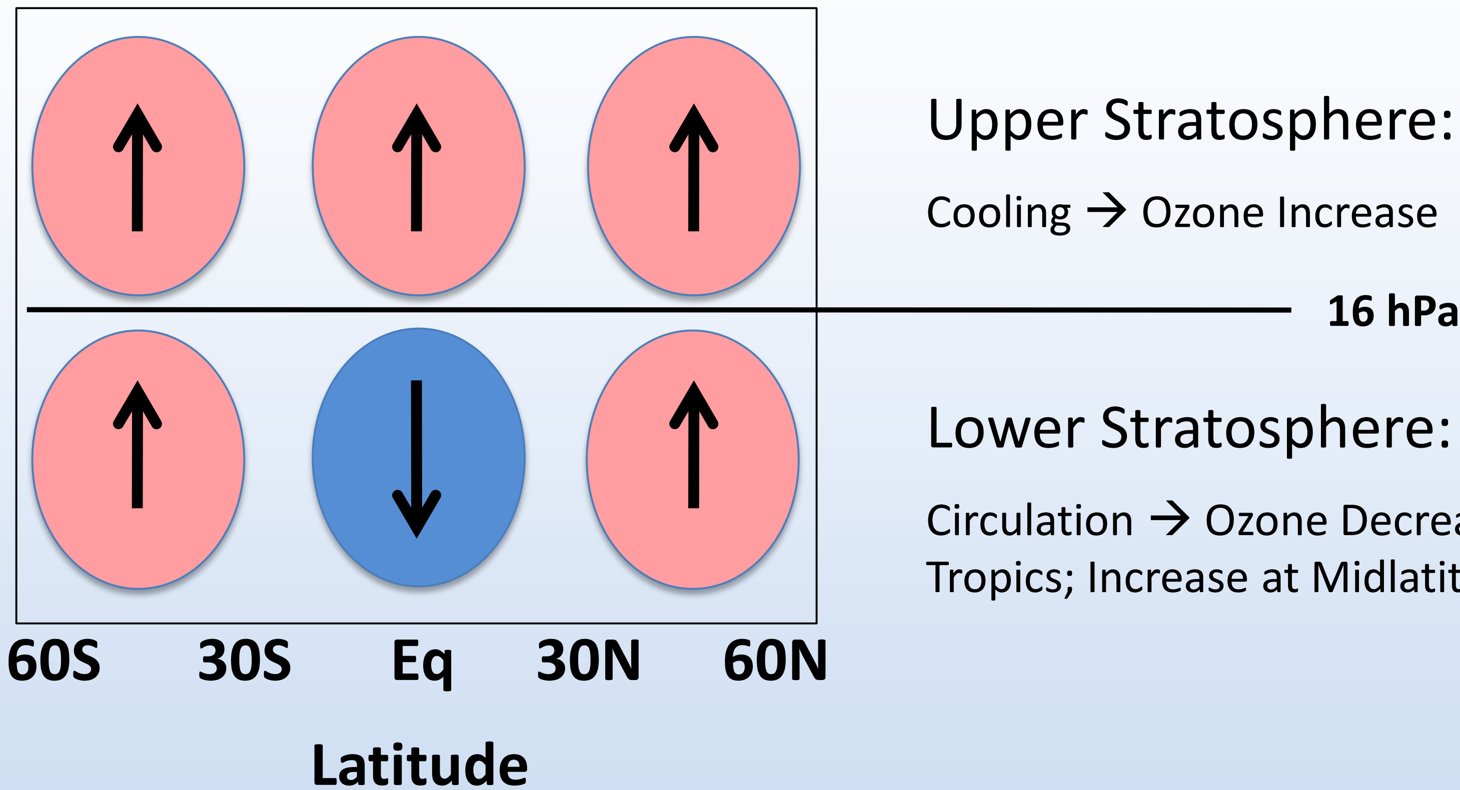
Results from the GEOS CCM 2065-1980

Li, F., et al. (2009), Stratospheric ozone in the post-CFC era, *Atmos. Chem. Phys., 9(6), 2207–2213.*

Net result is a column ozone increase at mid to high latitudes and almost no change near the equator



Expected Pattern for GHG Impact on Ozone



Upper Stratosphere:

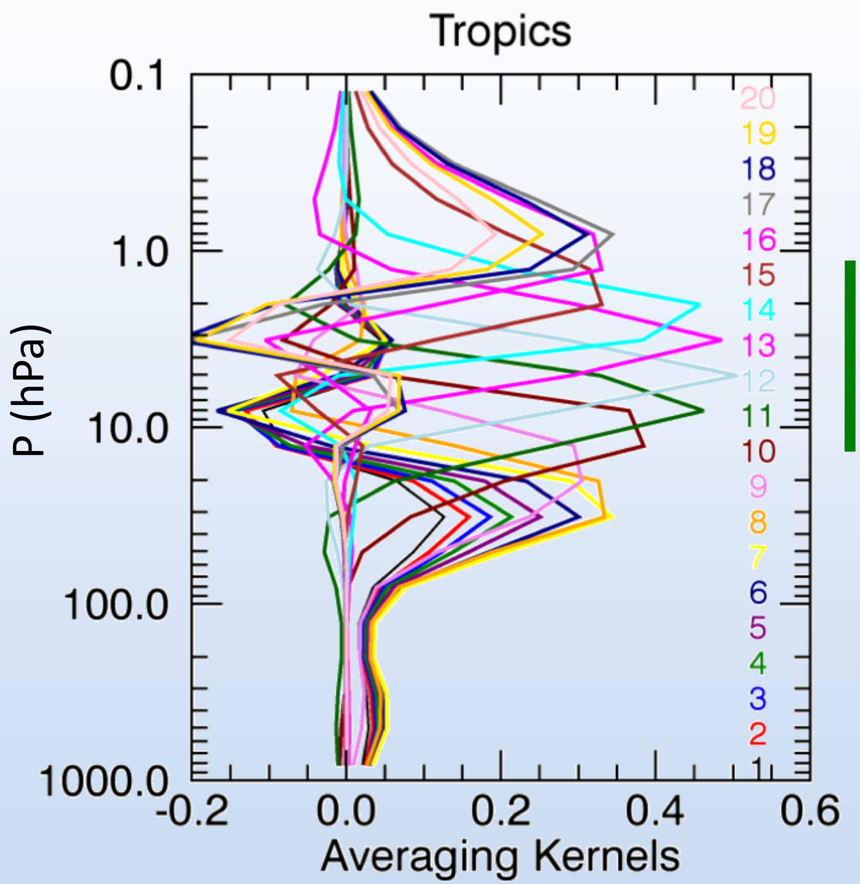
Cooling → Ozone Increase

Lower Stratosphere:

Circulation → Ozone Decrease in Tropics; Increase at Midlatitudes

SBUV Altitude Profiles

Instrument uses wavelength to scan in altitude

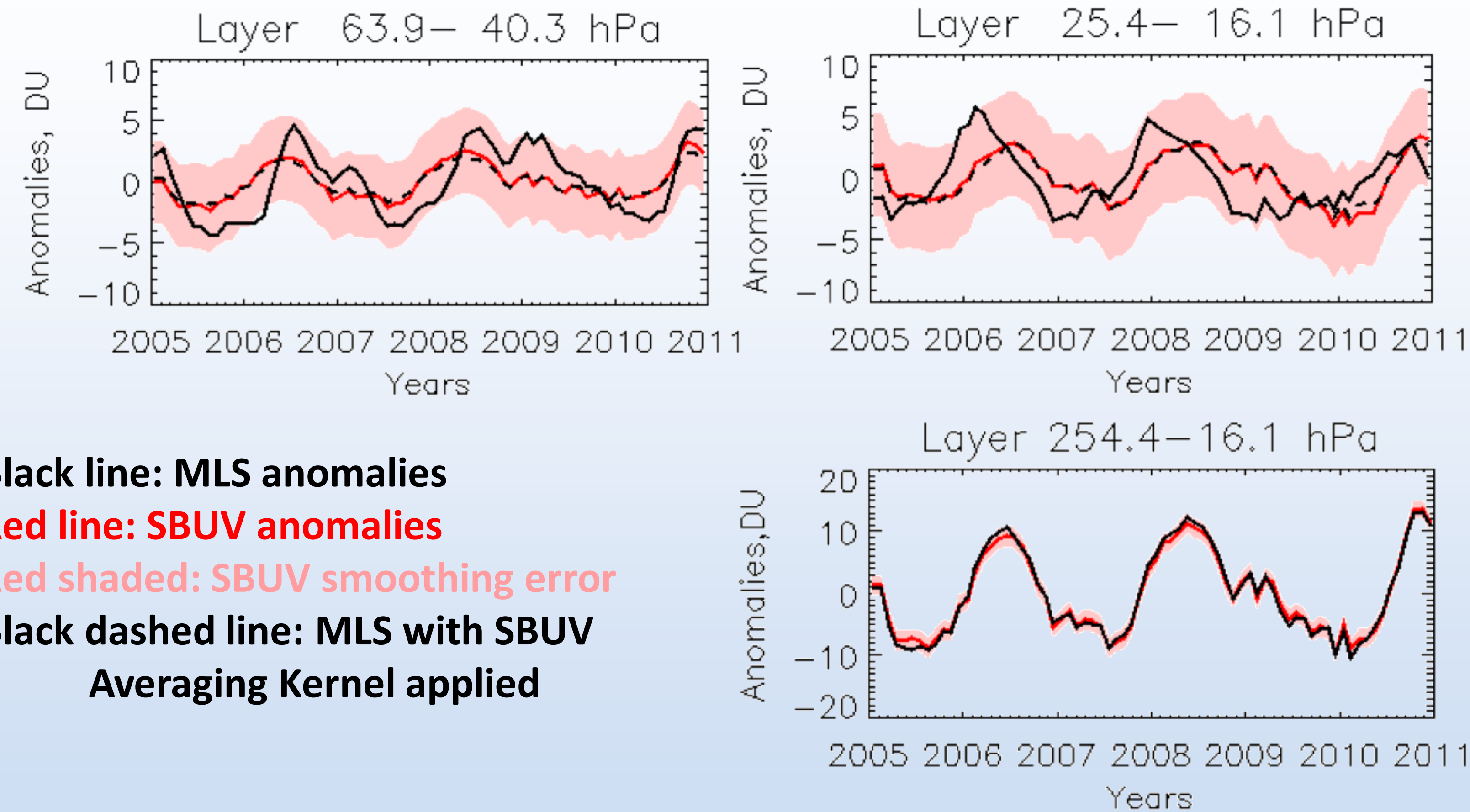


Good resolution in upper stratosphere

Poor resolution in lower stratosphere

SBUV Lower Stratospheric Measurements

Kramarova, N. et al. Atmos. Meas. Tech. 6, 2089-2099, 2013



Black line: MLS anomalies

Red line: SBUV anomalies

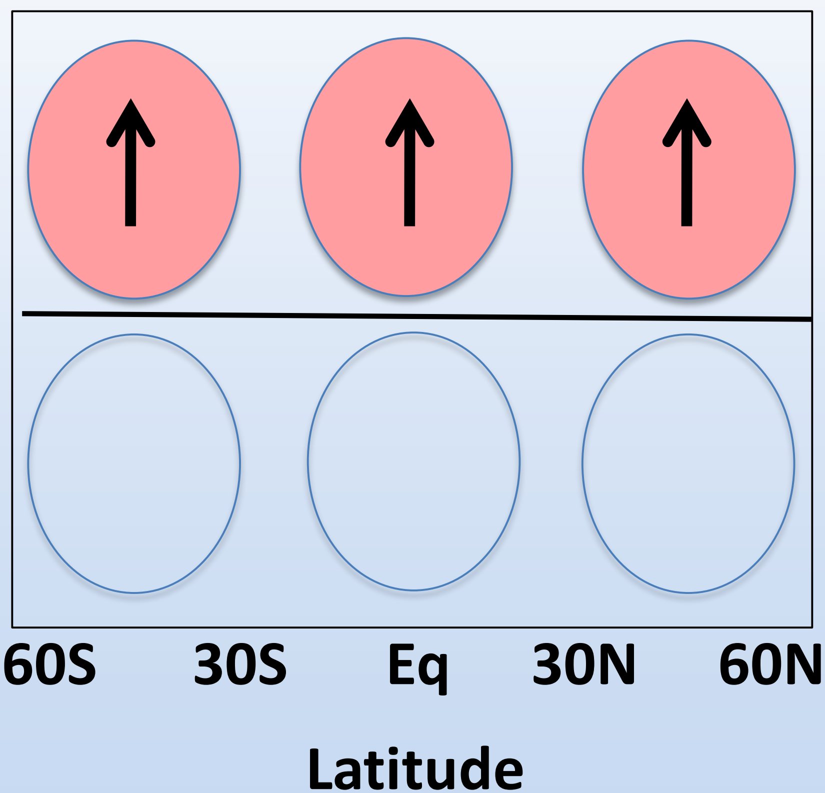
Red shaded: SBUV smoothing error

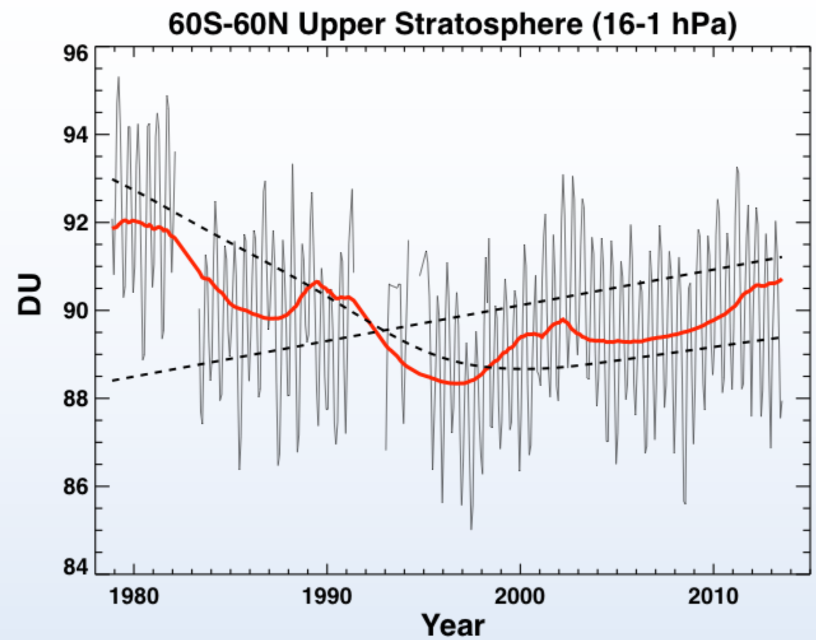
Black dashed line: MLS with SBUV Averaging Kernel applied

Conclusion: SBUV measurements, integrated over a broad vertical layer, provide an excellent data record for the lower stratosphere

Upper Stratosphere (16-1 hPa)

Fit to EESC, Solar Cycle, and Linear Trend

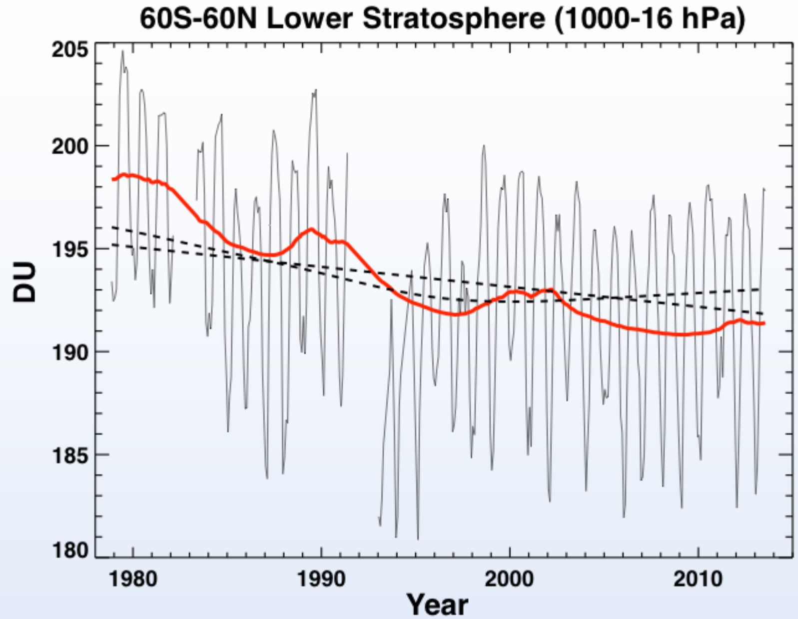


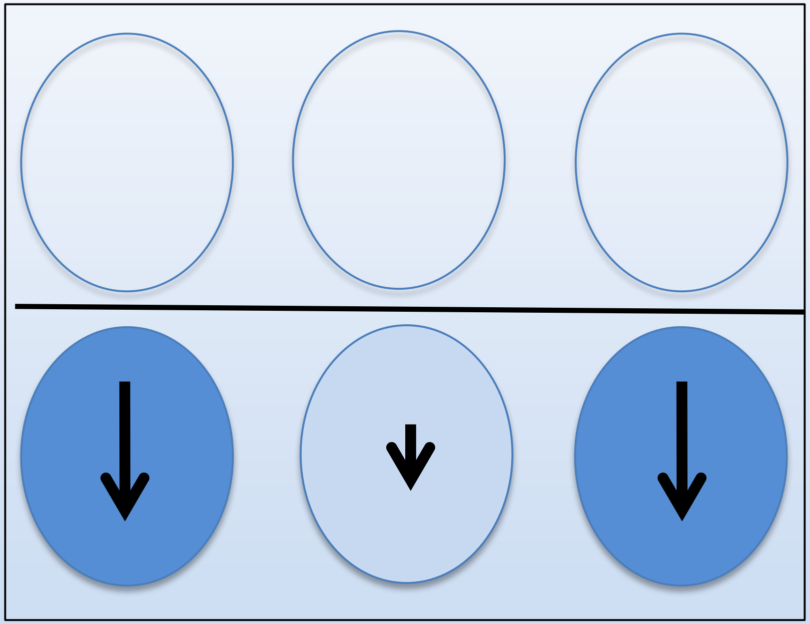


Upper Strat (16-1 hPa)	Trend (DU/decade)
60S-60N	+0.7 ± 0.4
60S-30S	+0.5 ± 0.3
30S-30N	+0.9 ± 0.6
30N-60N	+0.6 ± 0.4

Lower Stratosphere (1000-16 hPa)

Fit to EESC, Solar Cycle, and Linear Trend
+ QBO, Volcanos, ENSO





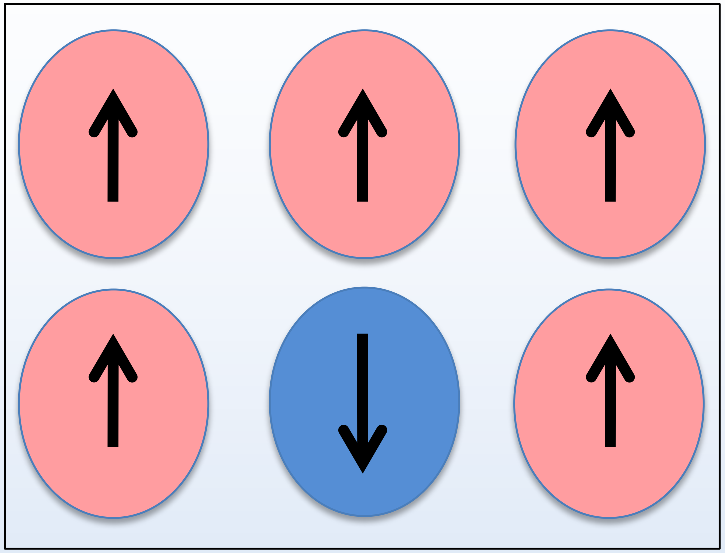
60S 30S Eq 30N 60N

Latitude

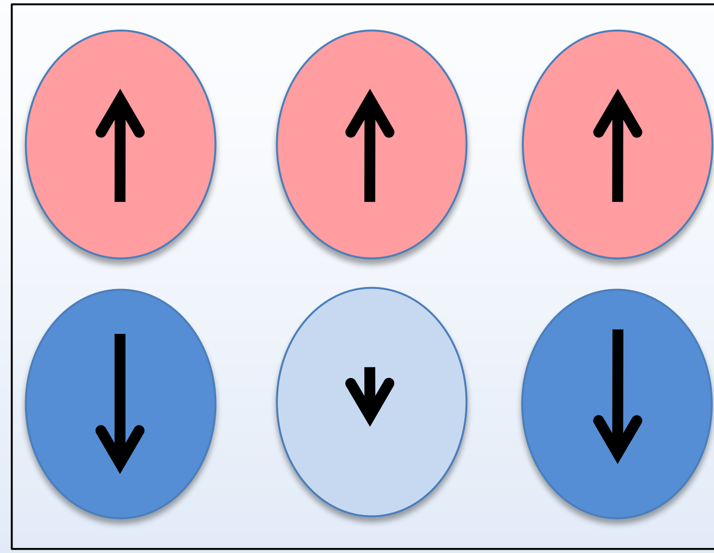
Lower Strat (1000-16 hPa)	Trend (DU/decade)
60S-60N	-1.4 ± 0.5
60S-30S	-2.3 ± 1.6
30S-30N	-0.8 ± 0.9
30N-60N	-2.0 ± 1.8

Summary

What we expect



What we see



○ **Upper stratospheric cooling shows positive ozone response as expected**

○ **Lower stratospheric ozone does not show evidence of circulation speed-up**

Conclusions

- **SBUV has continuous record of 35+ years**
- **Integrated lower stratosphere is excellent measurement**
- **Detect upward trend in upper stratosphere in addition to EESC fit: consistent with stratospheric cooling**
- **Do not detect signature of circulation speed-up**