The "Boulder Record": 30 Years of Water Vapor Vertical Profiles Over Boulder

NOAA

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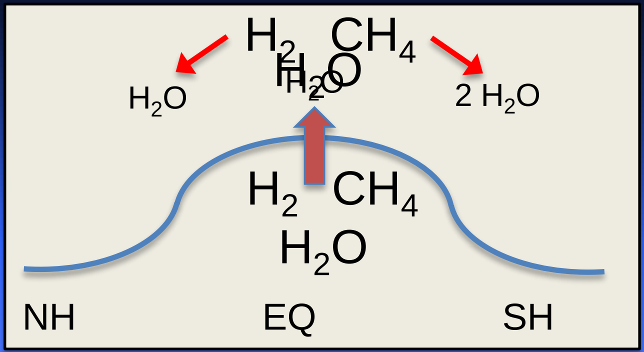
Stratospheric Water Vapor



Sources

Cross-tropopause transport of H_2O

Oxidation of stratospheric CH_4 and H_2

What can change stratospheric water vapor abundance?

Changes in tropical tropopause temperatures,
or when and where water vapor enters the stratosphere

Trends in stratospheric methane and/or hydrogen

Variations in the magnitude and frequency of deep convection events

Why is stratospheric water vapor important?

Atmospheric radiative balance

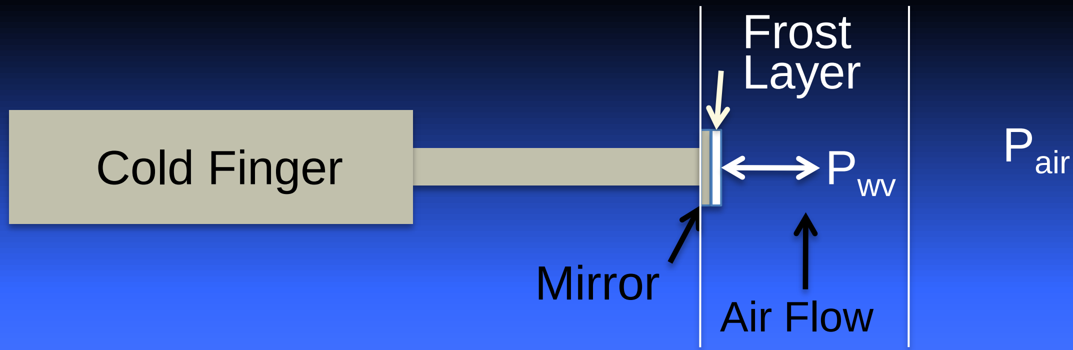
- change in $[H_2O]$ is most influential on OLR at the "cold point"

The 2000-2005 decrease in stratospheric water vapor slowed the rate of increase in global surface temperatures by 25%… *Solomon et al. [2010]*

Photochemical and microphysical mechanisms and rates

- atmospheric lifetimes of greenhouse gases, ozone-depleting gases
- cirrus cloud formation (UT), PSC formation

FPH Measurement Principle



The water vapor volume mixing ratio $\chi = P_{wv} / (P_{air} - P_{wv})$

- P_{WV} is calculated from the temperature of the stable frost layer (T_f)

χ is measured without a water vapor calibration scale or standards!

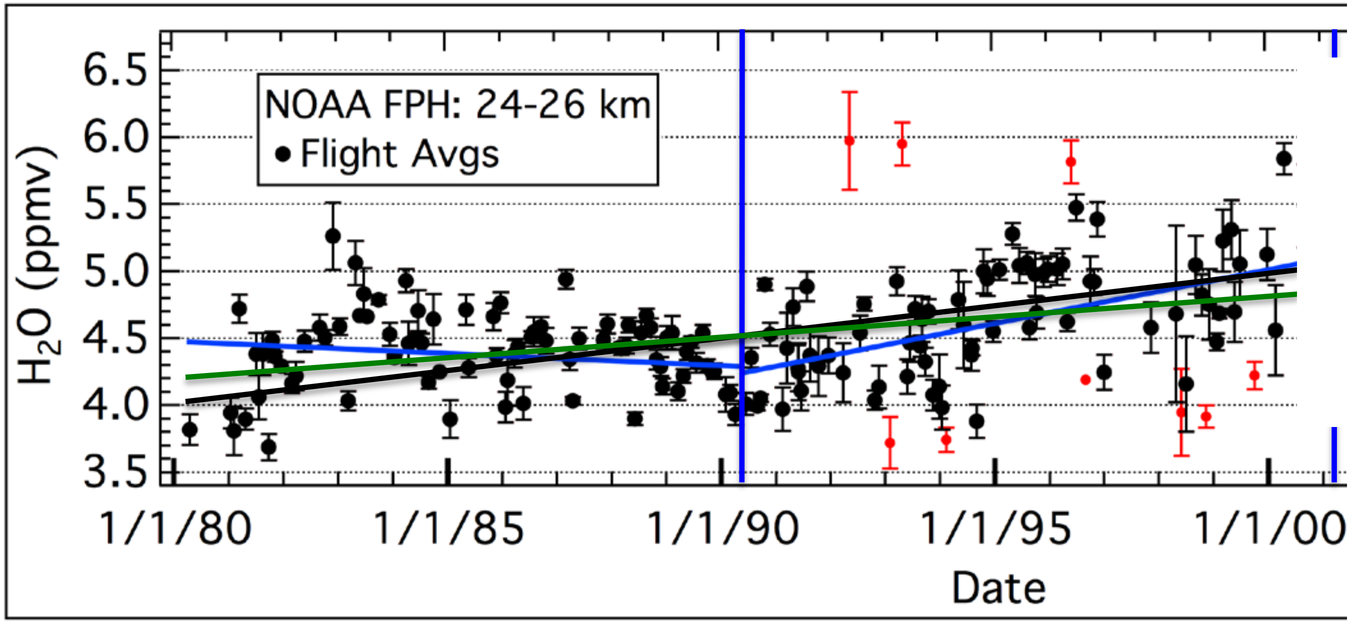
Simple calibration of:

- mirror thermistor (NIST-traceable temperature probe)
- pressure sensor for P_{air} (pre-launch calibration checks)

1st Boulder water vapor balloon launch:
April 14, 1980

The accuracy of measurements should be sustainable over long periods!

The “Boulder Record” (24-26 km layer): Trend Analyses



Publication	**Procedure**	**slope**	**95% confidence**
Oltmans et al. [2000]	simple LLS fit of averages	0.044	0.012 ppmv yr^{-1}
Scherer et al. [2008]	correction of low T_f simple LLS fit of averages	0.027	0.006 ppmv yr^{-1}

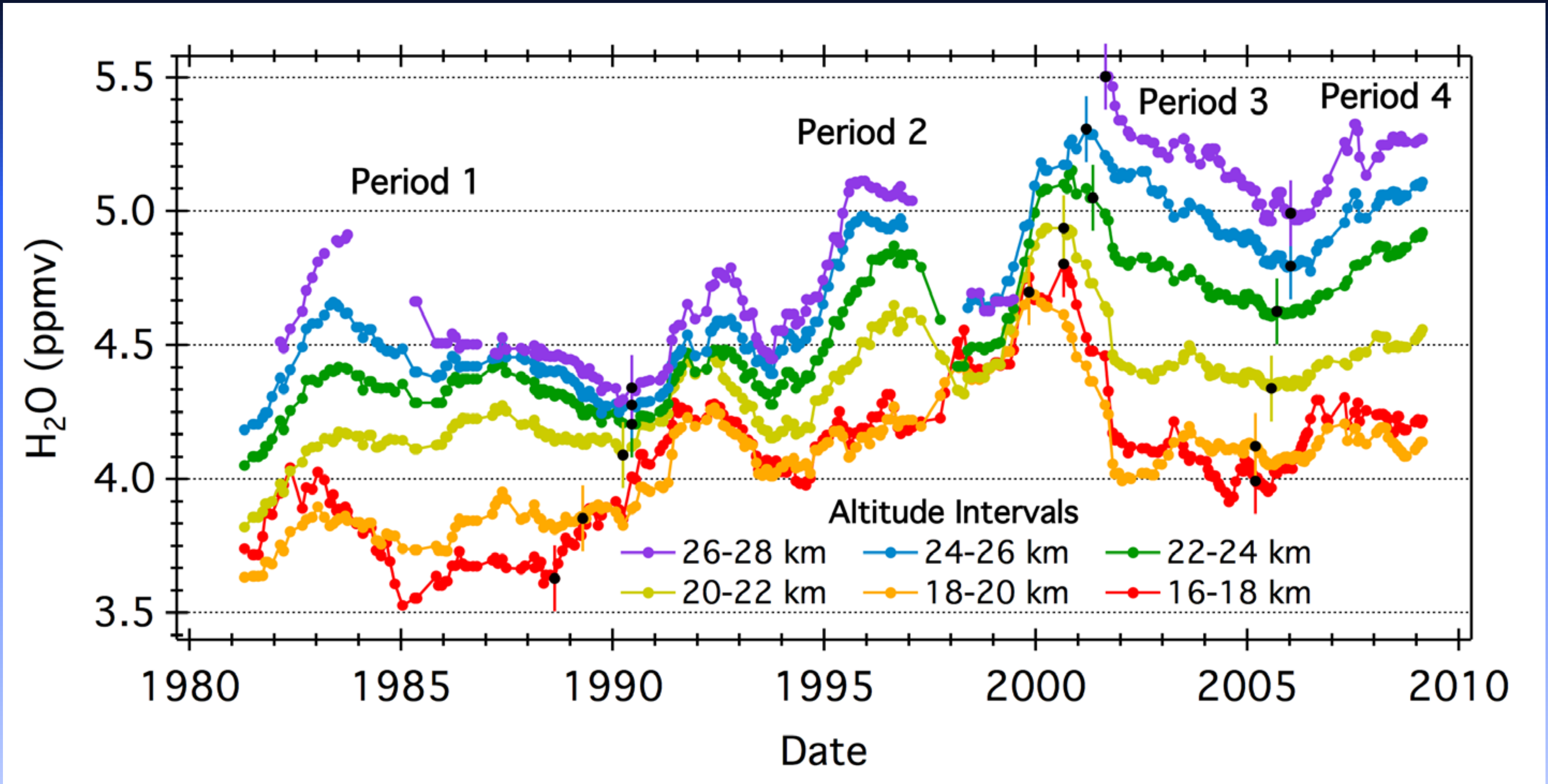
New Fit Method	weighted LLS fit of averages

Error bars are uncertainties of the individual flight averages

Statistical outliers were excluded from the linear fits

Re-evaluate trend periods

The smoothed “Boulder Record” (stratosphere only)

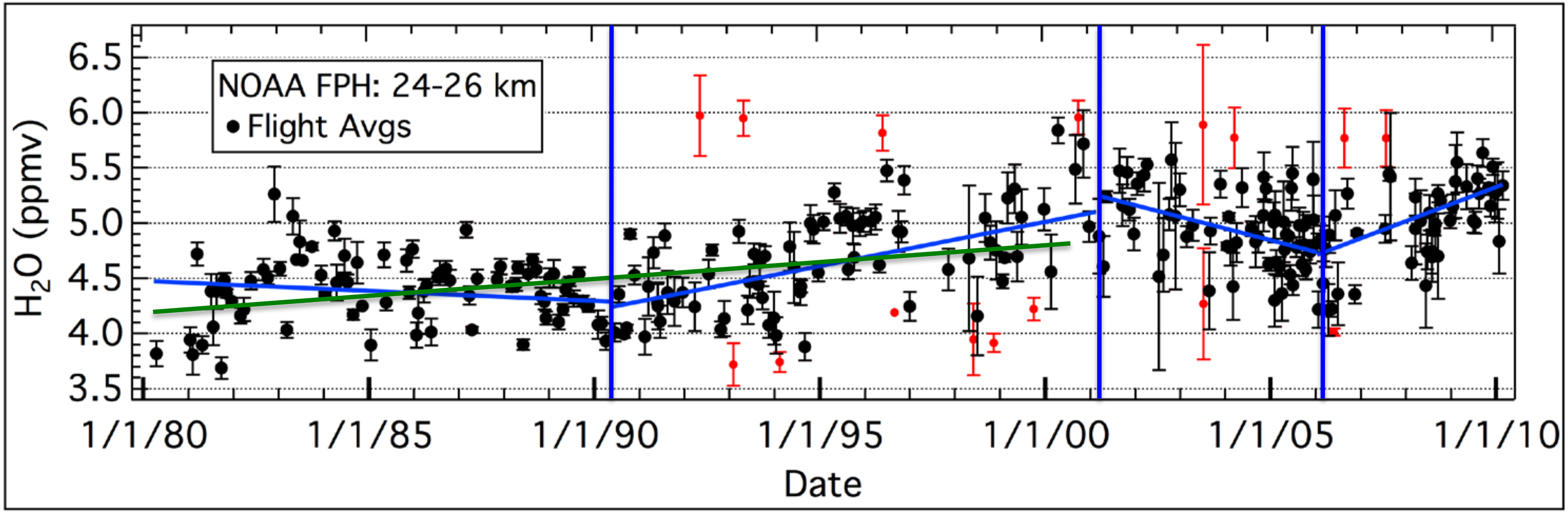


Moving averages: 1 yr windows, N ≥ 12 points

Trend analyses performed on individual flight data, not moving averages

Long gaps in the 26-28 km data preclude most trend determinations

New Trend Periods (24-26 km)



New 1980-1990 and 1991-2000 Results:		
1980-1990 (Period 1)	−0.018 0.004 ppmv yr^{-1} ;	Growth = −0.18 0.04 ppmv
1991-2000 (Period 2)	0.080 0.007 ppmv yr^{-1} ;	Growth = 0.86 0.08 ppmv

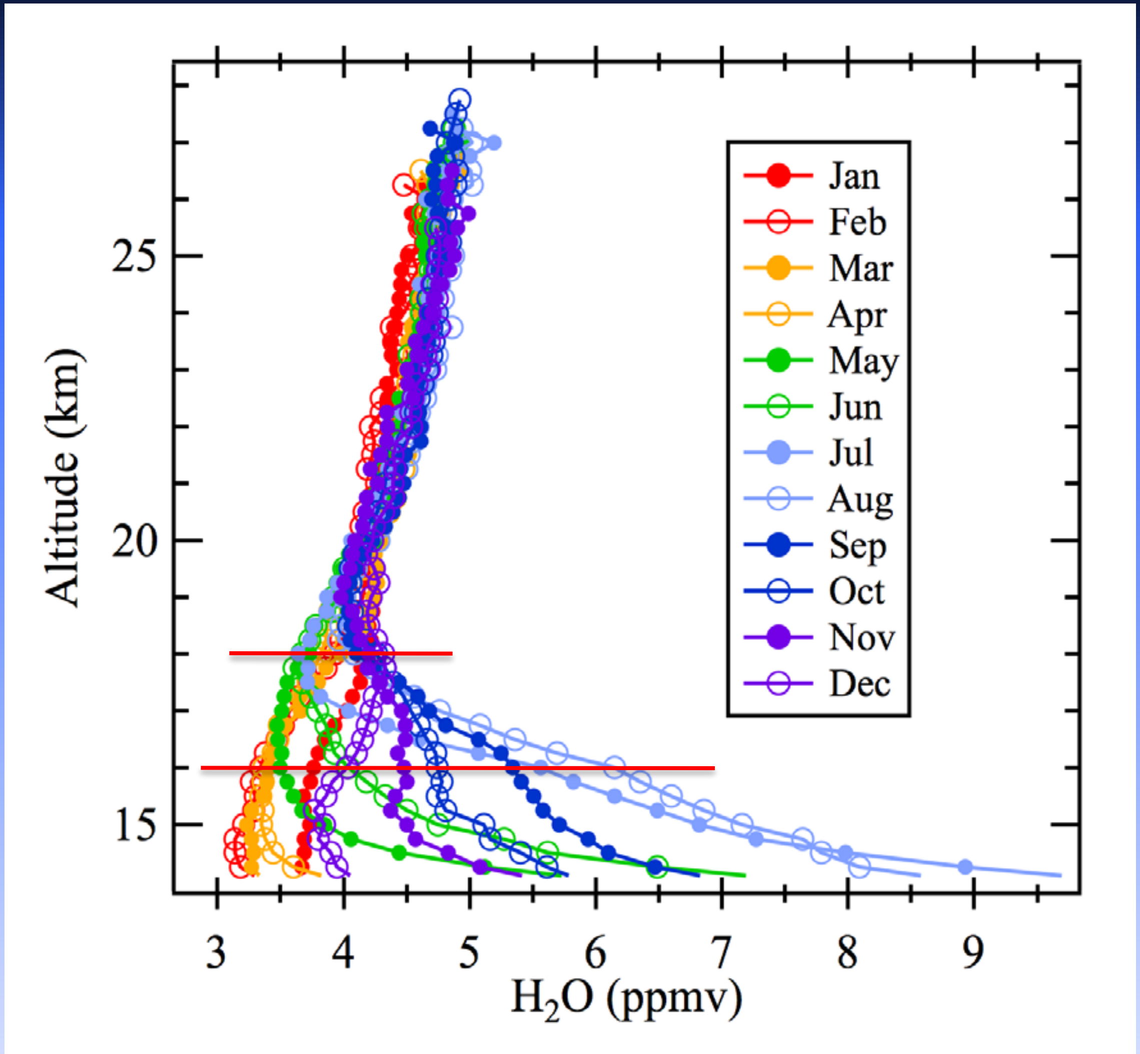
1980-2000 Growth = 0.68 0.09 ppmv

1980-2000:

Scherer et al. [2008] 0.027 0.006 ppmv yr^{-1} Growth = 0.54 0.12 ppmv

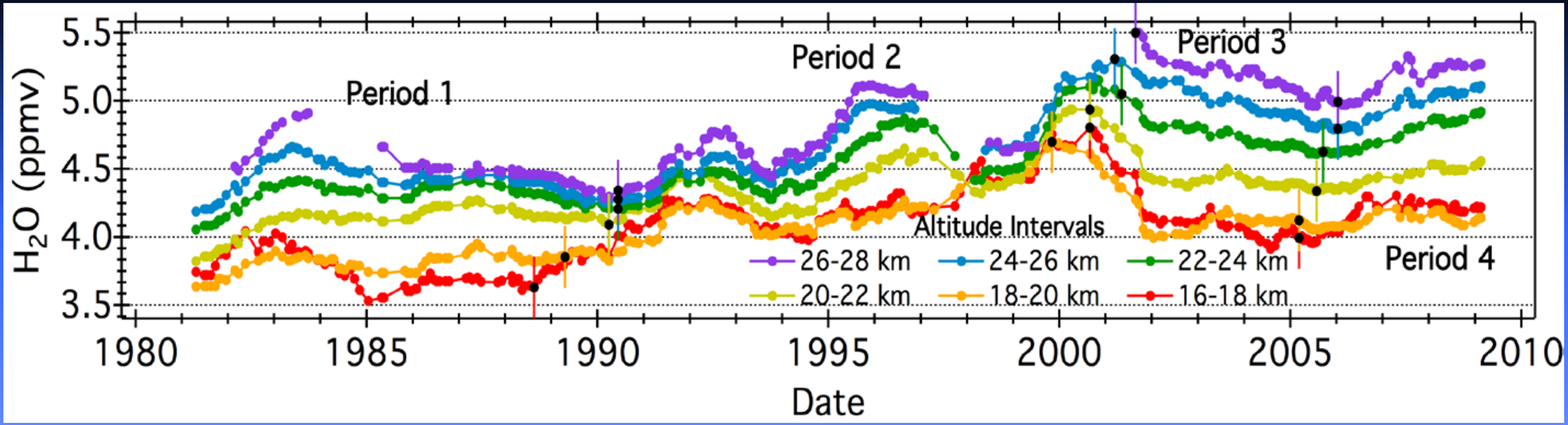
Concern about seasonal cycle influences on linear fits?

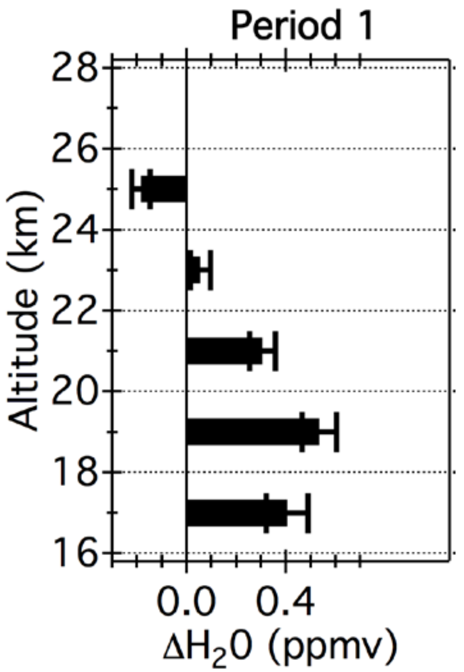
Monthly Mean Vertical Profiles over Boulder (30 years)



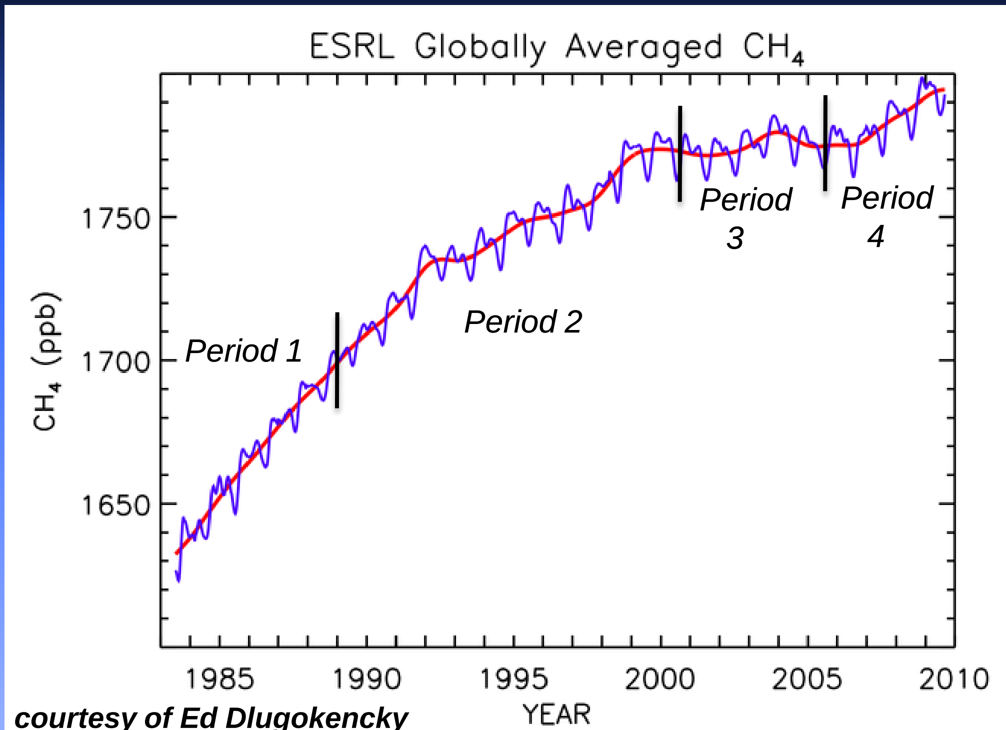
Trends determined for the deseasonalized 16-18 km data are <u>not</u> statistically different from trends derived from the original 16-18 km data

Growth in Stratospheric Water Vapor over Boulder





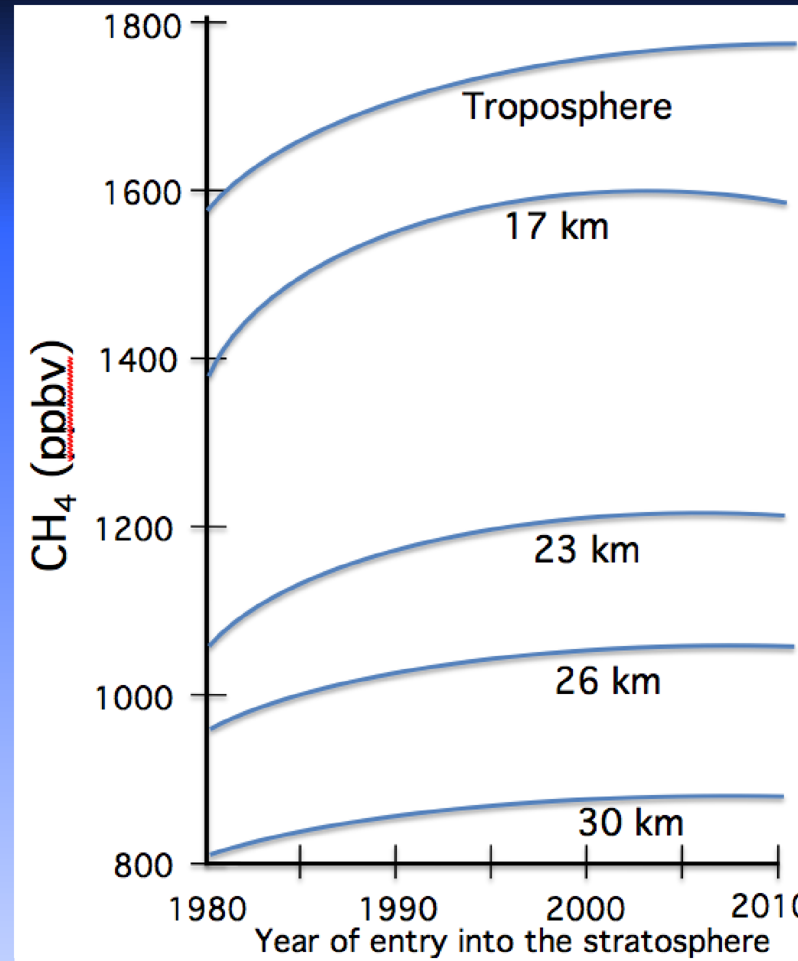
CH_4 Growth: Contributions to Water Vapor Growth



courtesy of Ed Dlugokencky

Is $\Delta H_2O_{(strat)} = 2 \bullet \Delta CH_{4(trop)}$? No!

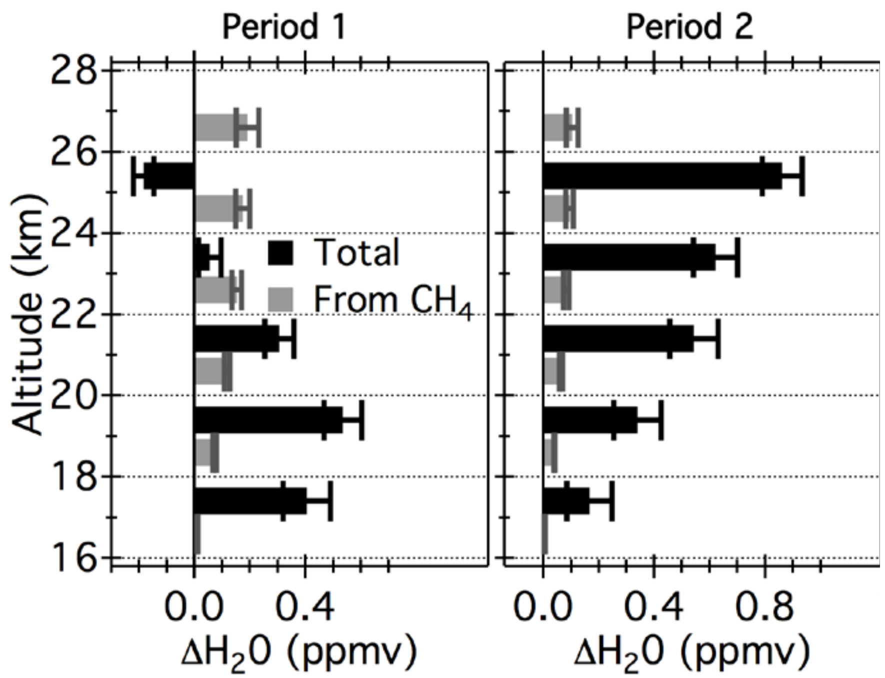
Altitude (km)	%CH4 oxidized
16-18	3
18-20	23
20-22	36
22-24	47
24-26	53



Adapted from Rohs et al. [2006]

No significant trend in H_2

Growth in Stratospheric Water Vapor over Boulder



Percentages of H_2O growth attributable to CH_4 growth (above 18 km)

Very mixed 15-300%	Consistent 11-14%	Mixed 13-40%	Mixed 18-37%

Other mechanisms at work beside CH_4 growth!

Water vapor changes in mid-latitudes originate in the tropical LS?

If so, why do Period 2 trends increase with altitude?

Recap

New Trend Analysis Method

- Measurement uncertainties employed in weighted fits
- Statistical outliers excluded from fits
- New trend periods significantly reduced residuals from trend lines

Newly Calculated Contributions from Methane Growth

- Altitude-dependent contributions
- Based on real measurements instead of model output

Water vapor growth:

1980-1989:	Mixed	Methane-induced WV growth was strong but WV growth at higher altitudes was weak or (-)
1990-2000:	Positive	12% contribution from strong CH_4 growth
2001-2005:	Negative	CH_4 growth was weak
2006-2010:	Positive	CH_4 growth was negligible

… stratospheric water vapor represents an important driver of decadal global surface climate change. *Solomon et al. [2010]*

The Rocky Mountains from 30 km altitude