Recent Divergences Between Stratospheric Water Vapor Measurements by Aura MLS and Frost Point Hygrometers

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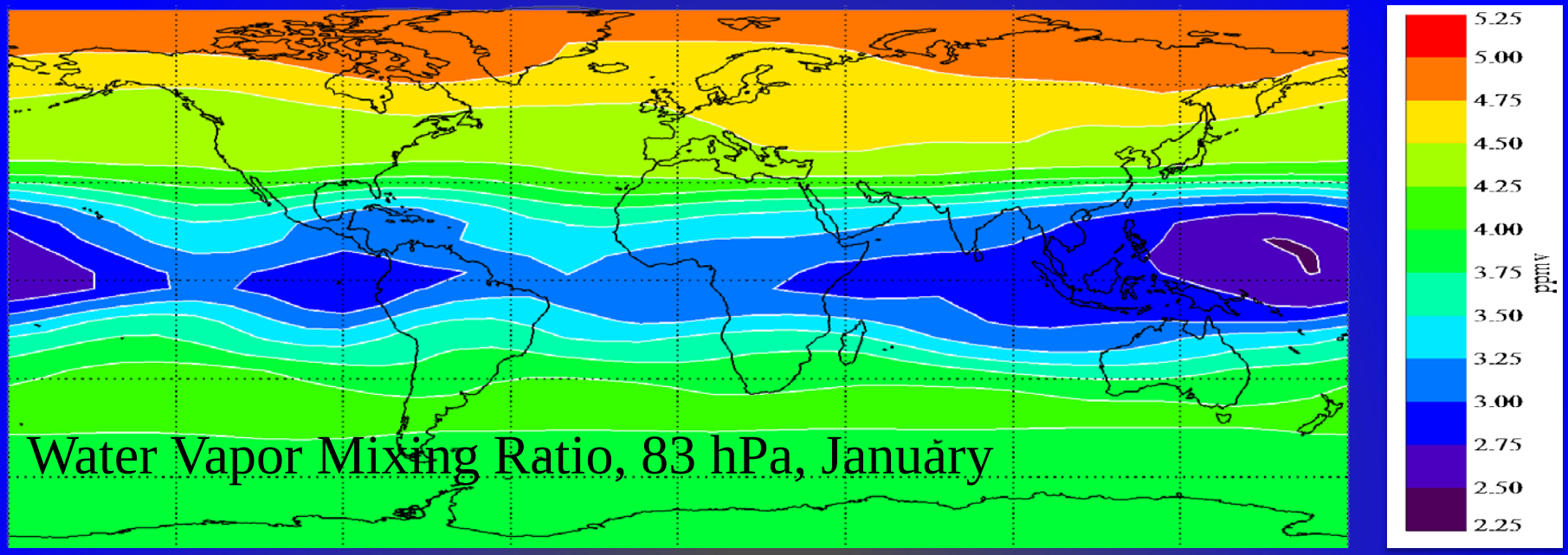
Aura Microwave Limb Sounder (MLS)



Aura MLS

Operational since August 2004

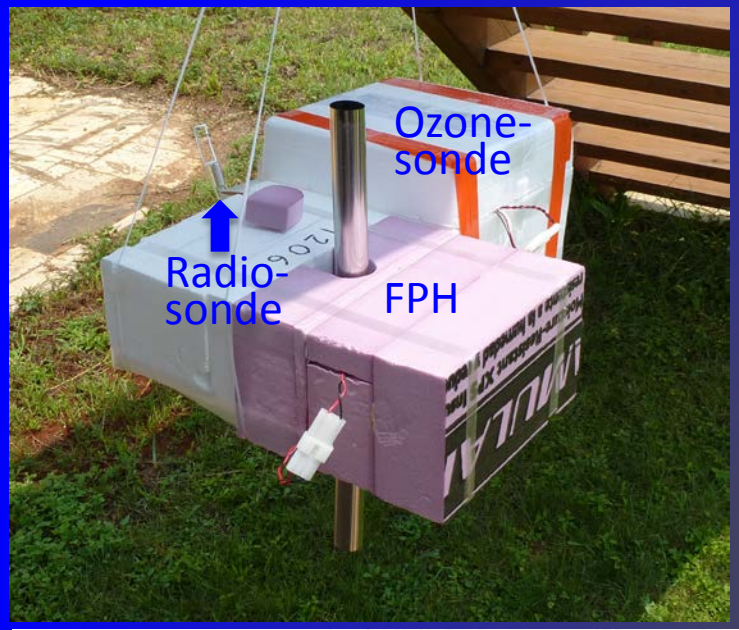
~3500 profiles per day

316 hPa to well above 0.1 hPa
(this study: 100 to 26 hPa)

Near-global coverage

Accuracy: 0.2-0.3 ppm (5-8%)

Frost Point Hygrometers: NOAA FPH and CFH



Monthly Soundings

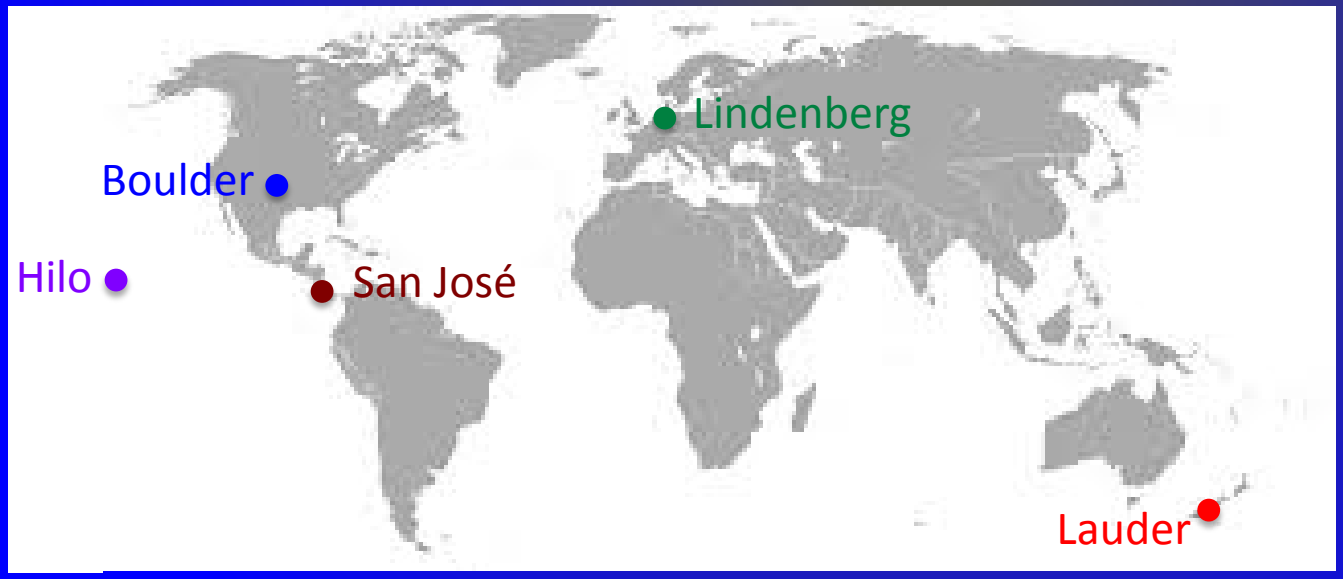
Surface to ~28 km

5 sites world-wide

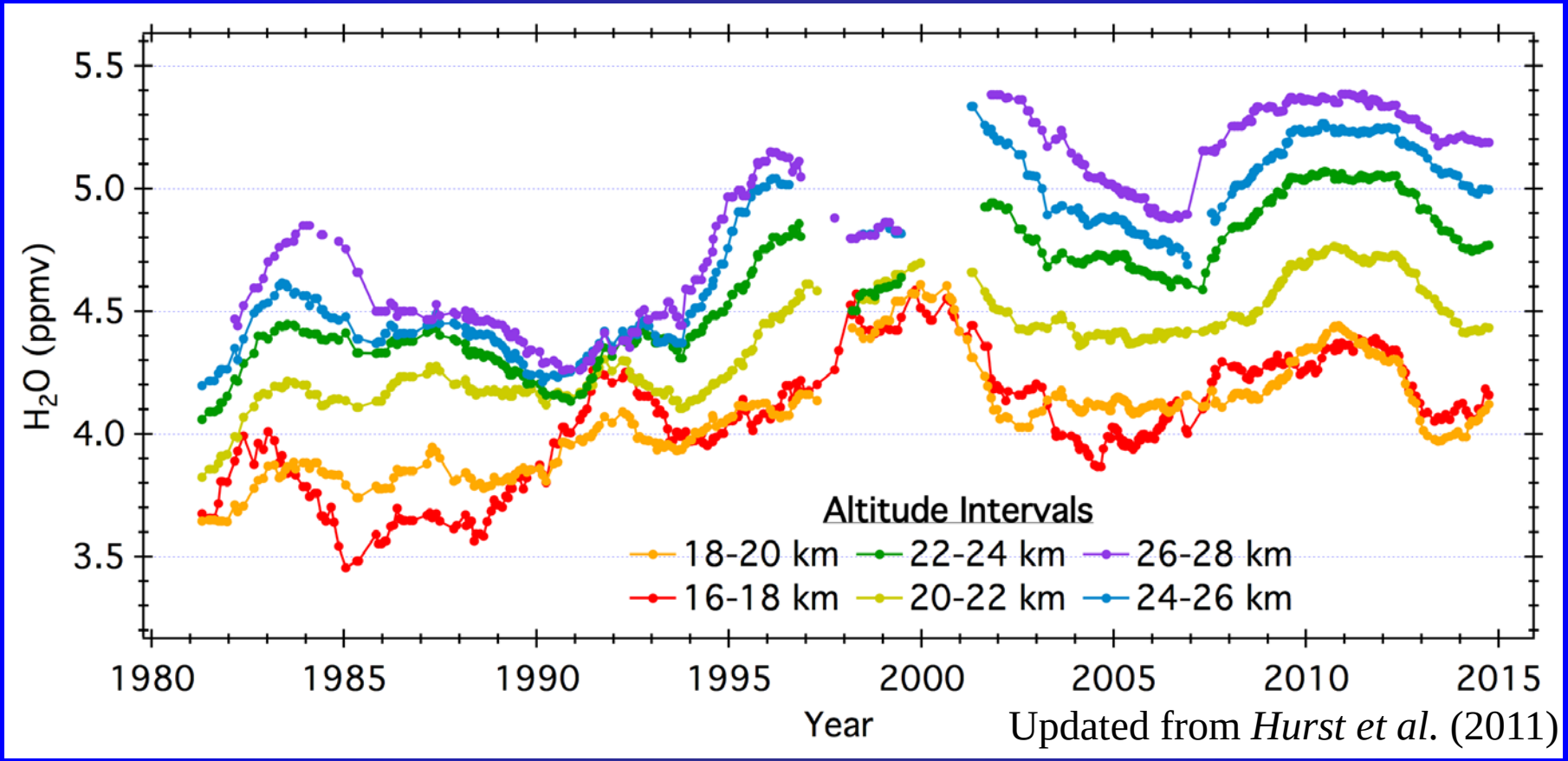
Boulder since 1980

Others began >2003

Accuracy: 0.3-0.5 ppm
(5-10%)



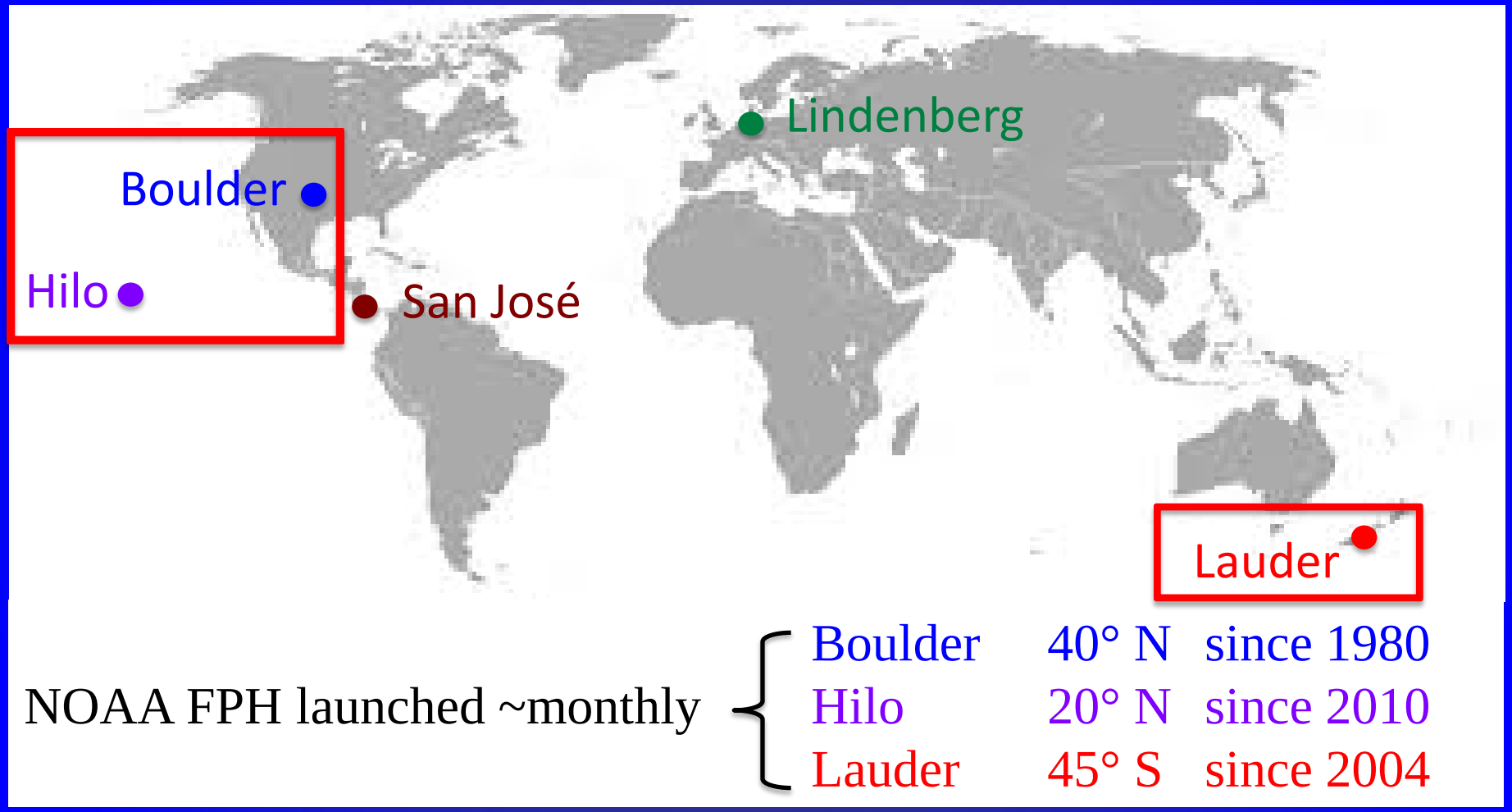
SWV over Boulder: 1980–2015
412 FPH Soundings



Net 30-year increase ~1% yr^{-1}

Maximum increase ~0.3% yr^{-1} from CH_4 growth

Comparison of FPH with MLS version 3.3 (2004-2012)

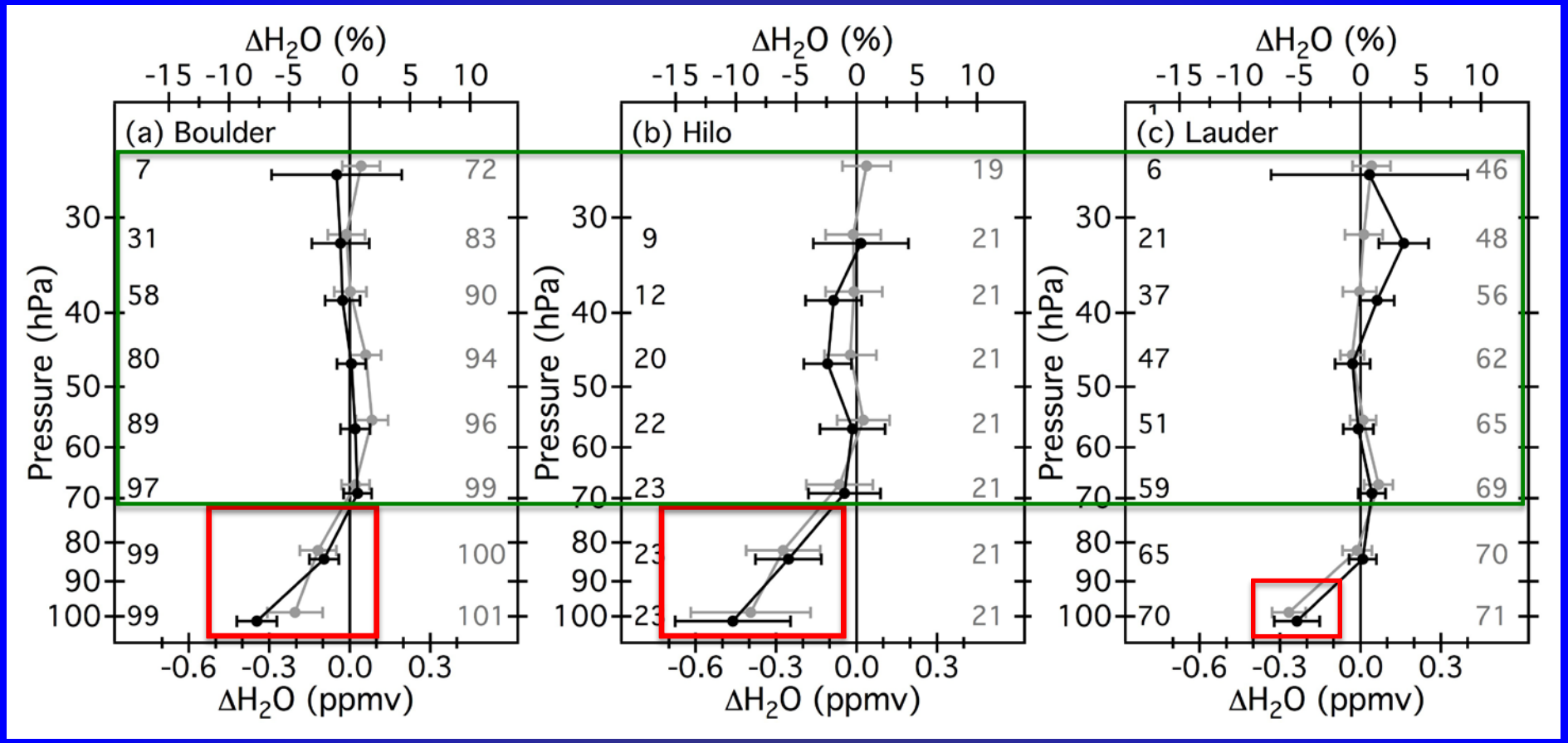


NOAA FPH launched ~monthly

Boulder	40° N	since 1980
Hilo	20° N	since 2010
Lauder	45° S	since 2004

- FPH-MLS Coincidence: ±16 hours, ±2° latitude, ±8° longitude
  4-6 MLS profiles per FPH sounding => MLS profile of median mixing ratios
- FPH profiles are convolved with the MLS averaging kernels

2004-2012 Comparison of FPH with MLS version 3.3: Biases



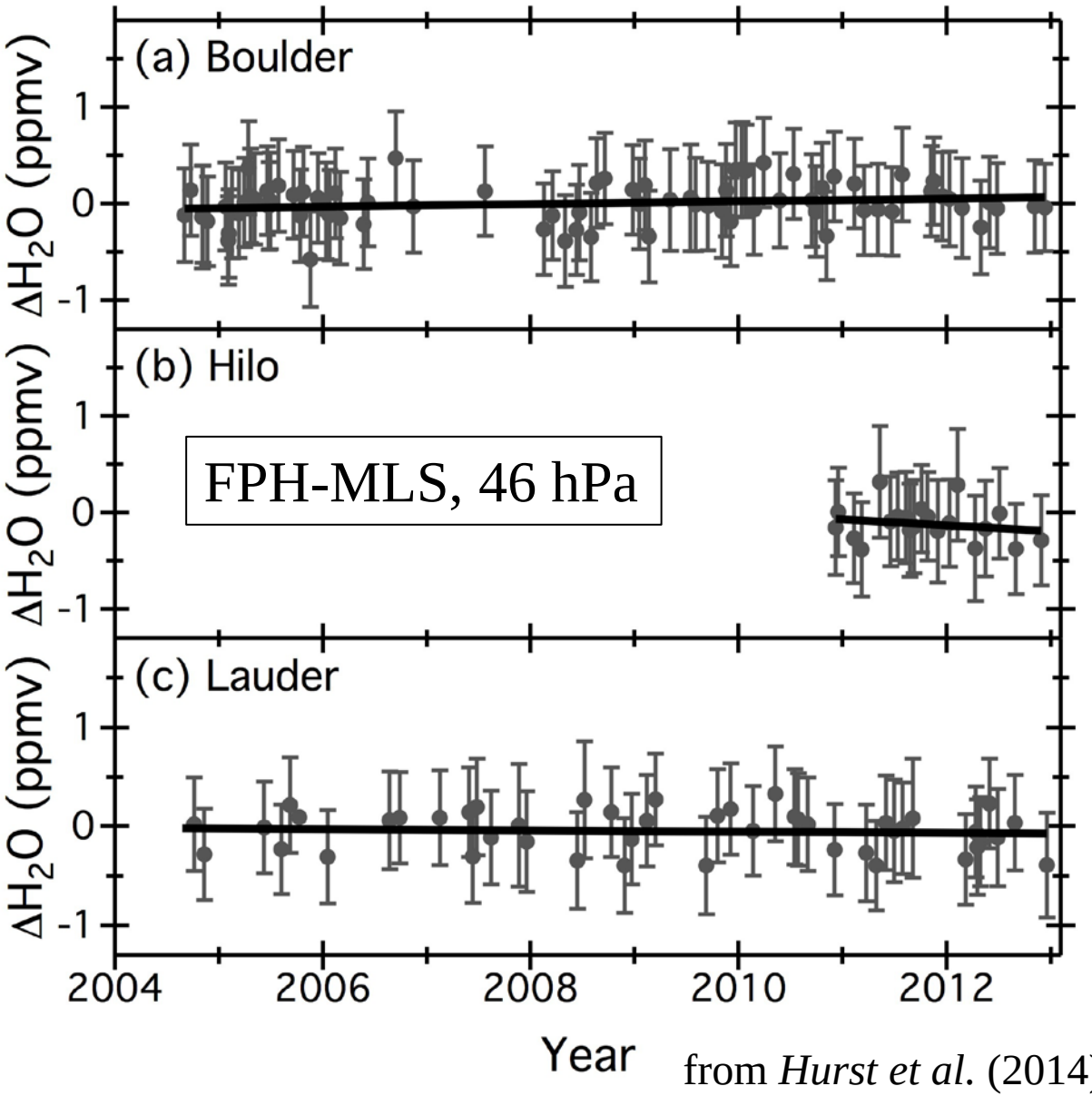
from *Hurst et al.* (2014)

Mean Biases

68 to 26 hPa: most are <0.04 ppm (<1%): not statistically significant

83 and 100 hPa: -0.10 to -0.46 ppm (-2 to -10%): significant biases

2004-2012 Comparison of FPH with MLS version 3.3: Drifts



from *Hurst et al.* (2014)

Linear Regression Fits to full time series

24 linear fits
(8 levels over 3 sites)

⇒ 22 were not statistically significant (95%)

⇒ 2 were significant, ~0.04 ppm yr^{-1}

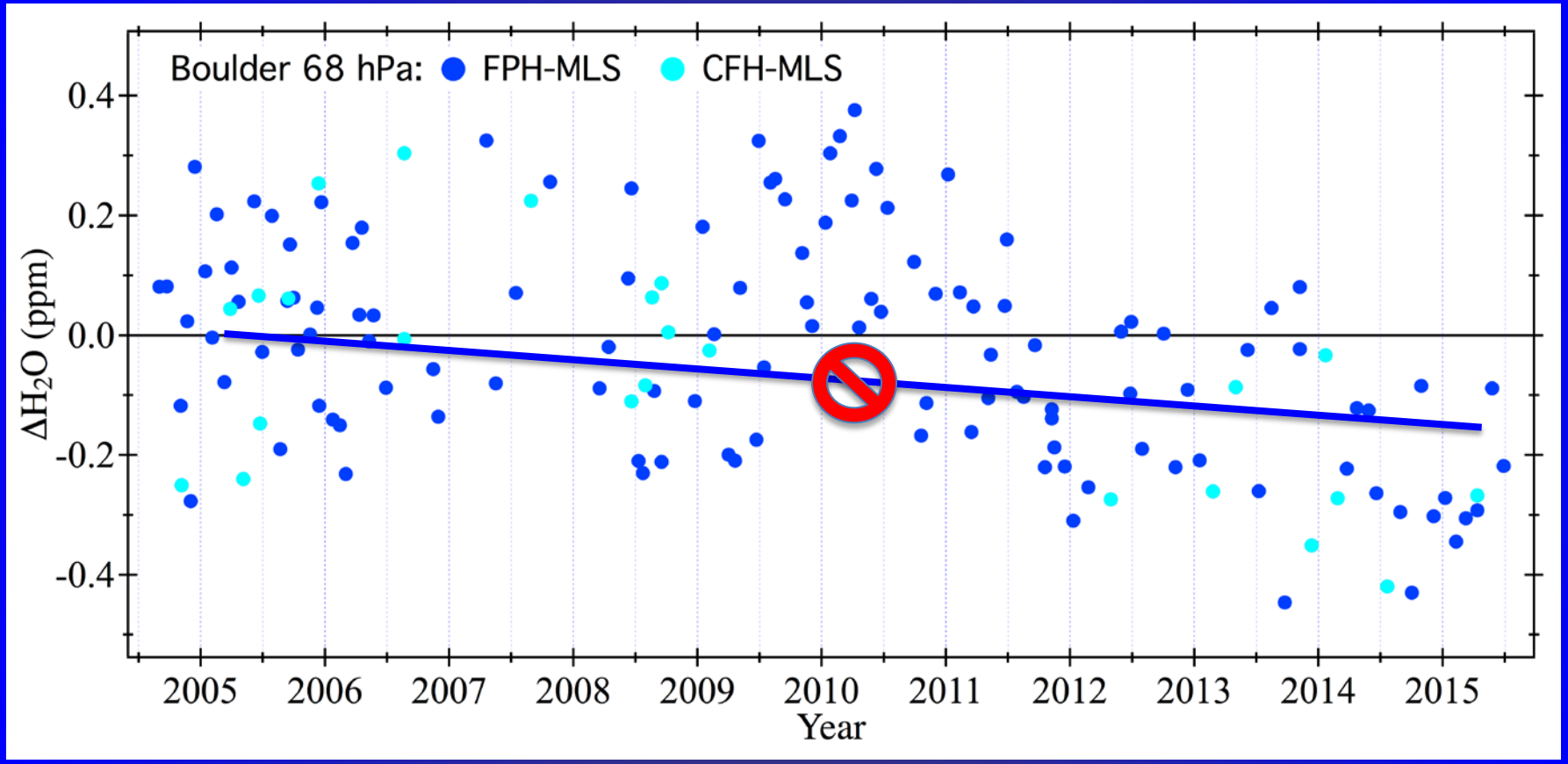
No compelling evidence of drifts between FPH and MLS, 2004-2012

FPH and CFH Comparisons with MLS v3.3 (2004-2015.5)

FPH at: Boulder, Hilo and Lauder

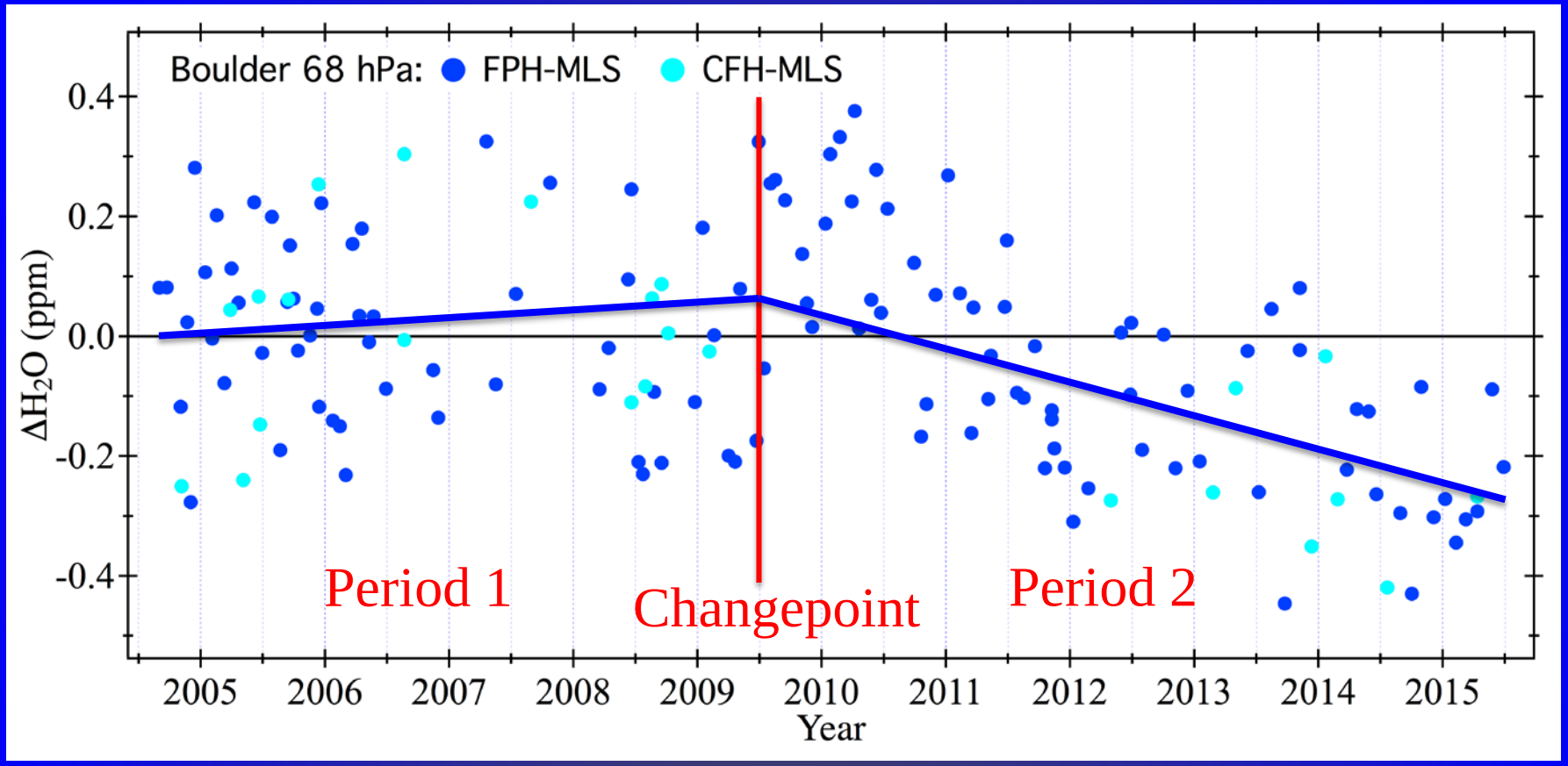
CFH at: San José (10° N) and Lindenberg (52° N)

FPH and CFH Comparisons with MLS v3.3 (2004-2015.5)
Boulder, Colorado



Drift Analysis using Standard Linear Regression?

FPH and CFH Comparisons with MLS v3.3 (2004-2015.5)



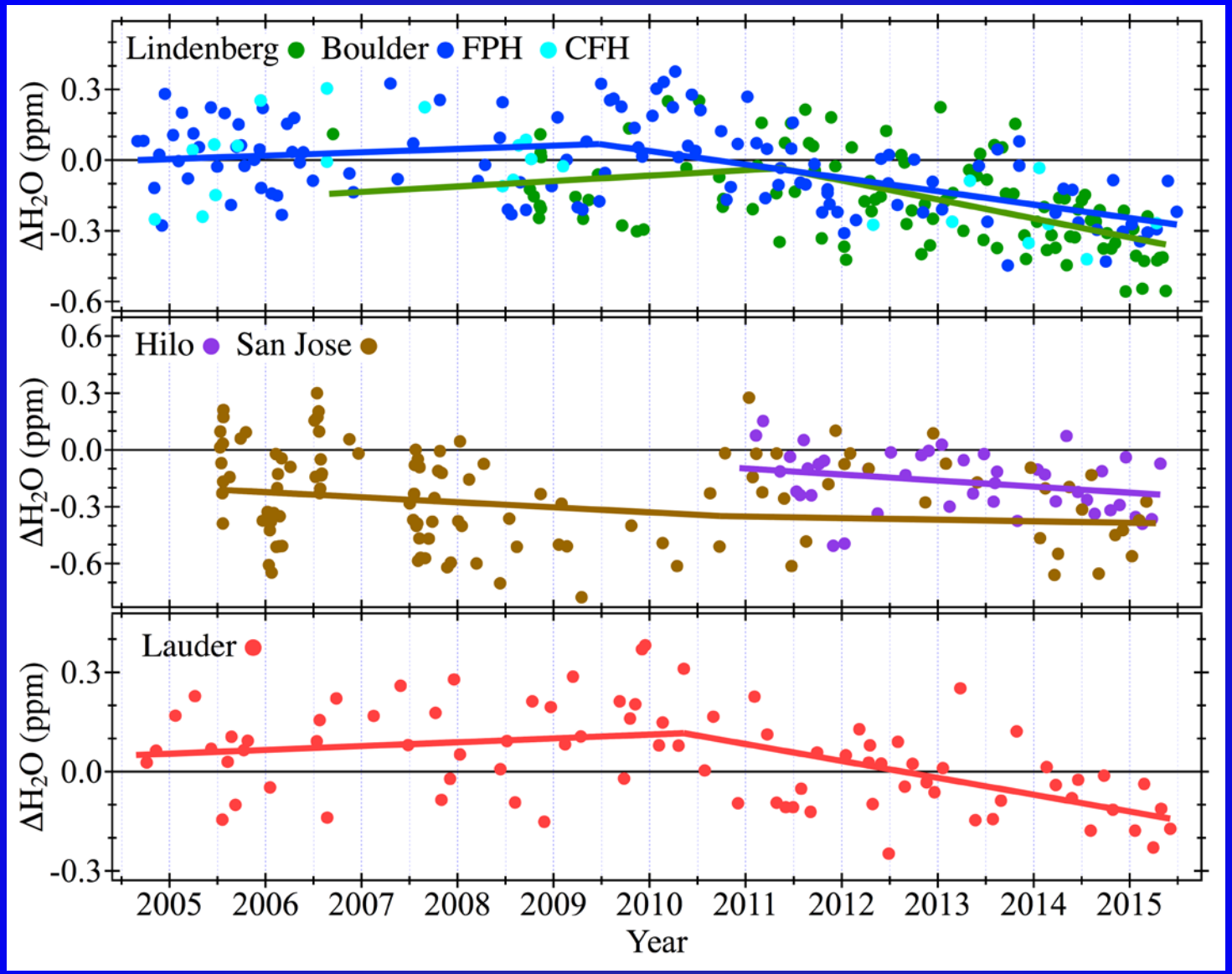
1. Test for statistical changepoints using *Lund and Reeves* (2002)

   "time where the mean of a series first undergoes a structural pattern change"

2. Significant (>90% CL) changepoints detected in 24/ 32 records

   fit each time series using weighted piecewise continuous linear regression instead of standard linear regression

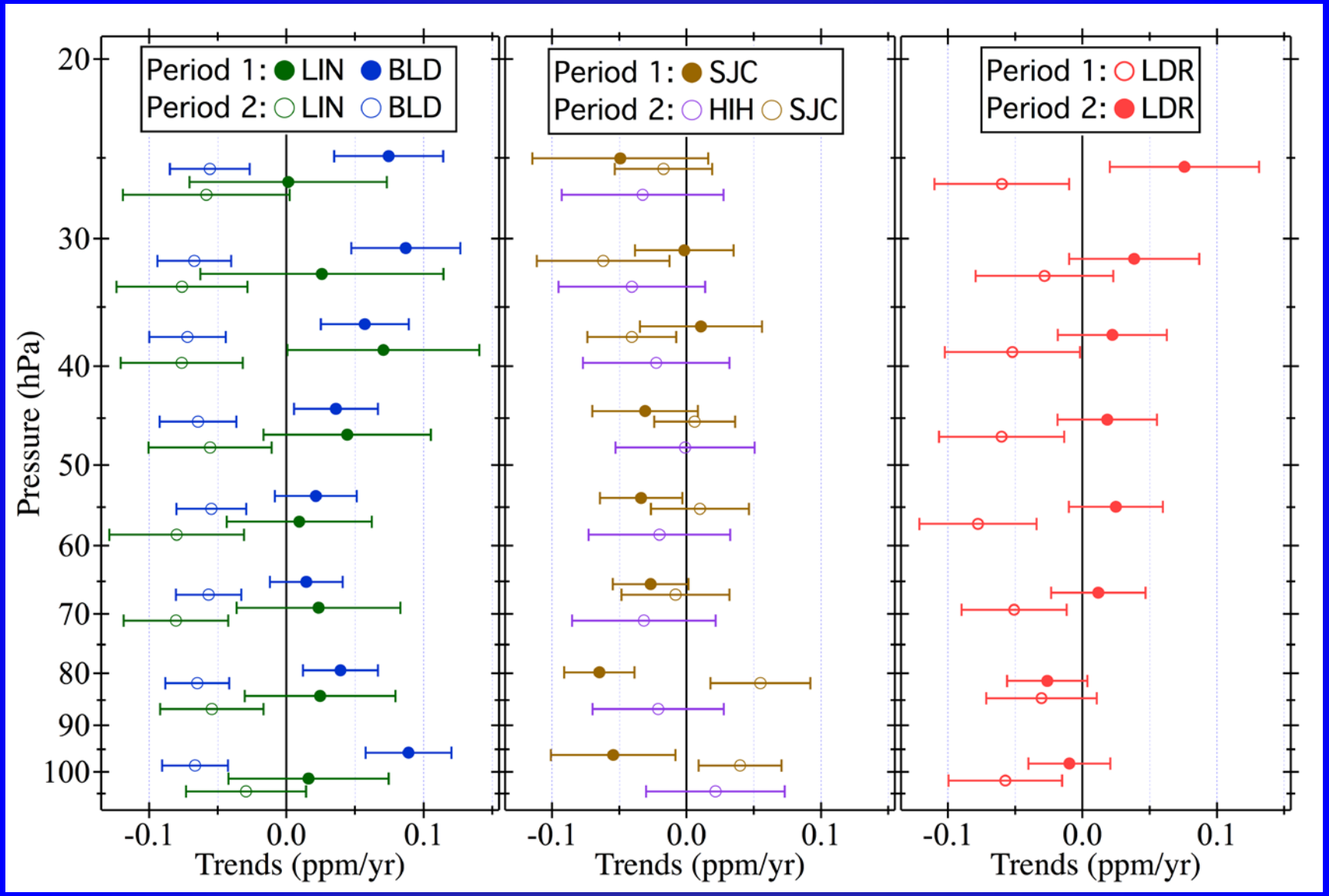
FP–MLS v3.3 at 68 hPa (2004-2015.5)



Changepoint Dates
mid-2009 to early 2011

Almost all Period 2 trends are negative

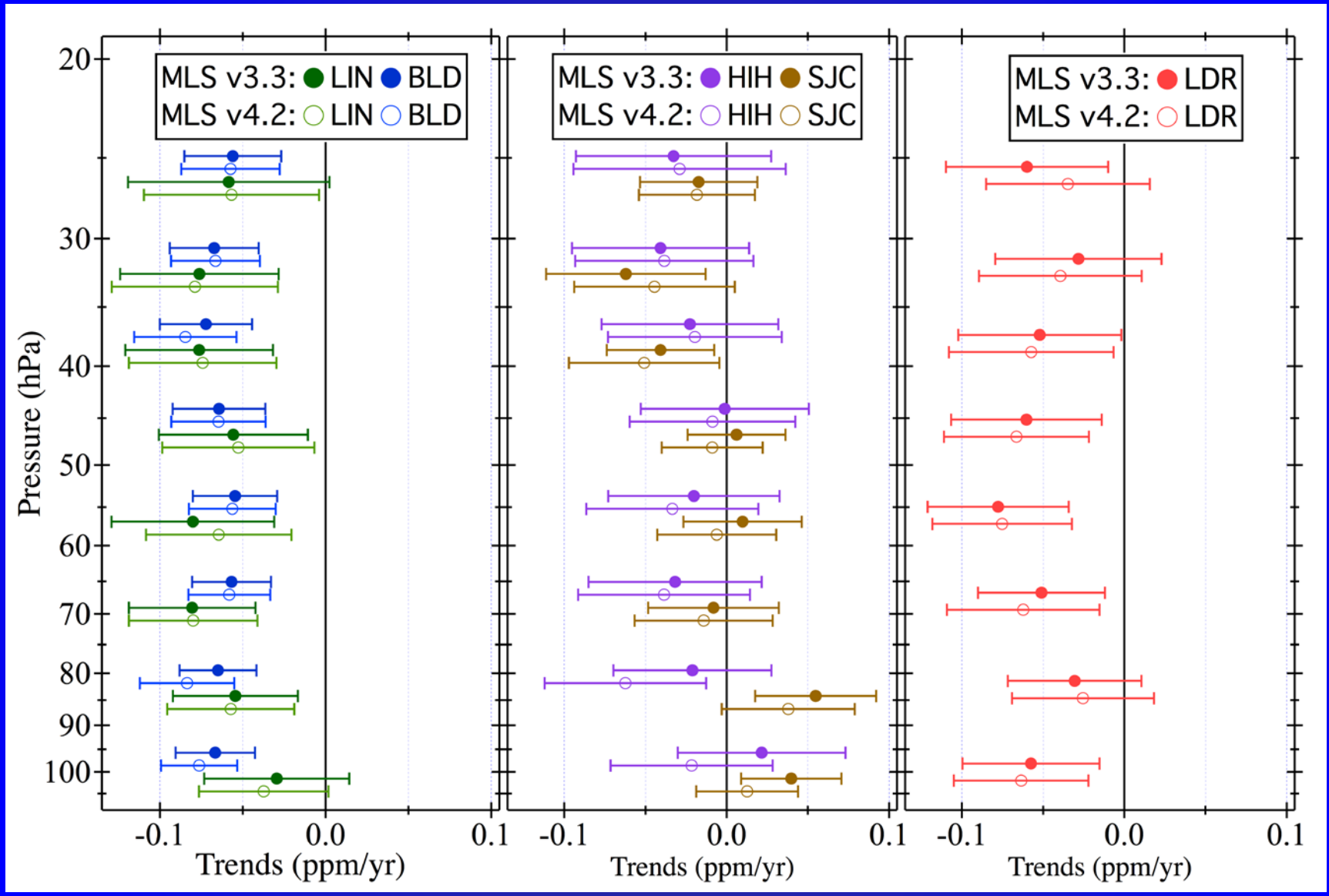
Trends in FP–MLS v3.3 for Periods 1 and 2



Many Period 2 trends are negative and statistically significant (95% CL)

14 of 16 | 2 of 16 | 6 of 8

Period 2 Trends in FP–MLS: MLS v3.3 and v4.2



No significant differences in results for MLS v3.3 and v4.2

Stratospheric Average Trends and Changes in FP–MLS

Site	MLS Version	Period 1 Trend (ppm/yr)	Period 1 Change (ppm)	Period 2 Trend (ppm/yr)	Period 2 Change (ppm)	Full Record Change (ppm)
Lindenberg	3.3	**0.026 ± 0.022**	**0.13 ± 0.11**	**-0.064 ± 0.016**	**-0.25 ± 0.06**	-0.12 ± 0.12
Lindenberg	4.2	**0.037 ± 0.023**	**0.18 ± 0.11**	**-0.062 ± 0.015**	**-0.25 ± 0.06**	-0.08 ± 0.13
Boulder	3.3	**0.047 ± 0.011**	**0.22 ± 0.05**	**-0.063 ± 0.009**	**-0.39 ± 0.06**	**-0.16 ± 0.08**
Boulder	4.2	**0.044 ± 0.011**	**0.22 ± 0.05**	**-0.068 ± 0.010**	**-0.41 ± 0.06**	**-0.19 ± 0.08**
Hilo	3.3			-0.018 ± 0.019	-0.08 ± 0.09	
Hilo	4.2			**-0.032 ± 0.019**	**-0.15 ± 0.09**	
San José	3.3	**-0.034 ± 0.013**	**-0.16 ± 0.06**	-0.002 ± 0.013	0.01 ± 0.07	**-0.13 ± 0.09**
San José	4.2	**-0.019 ± 0.012**	**-0.09 ± 0.06**	-0.008 ± 0.013	-0.04 ± 0.07	**-0.13 ± 0.09**
Lauder	3.3	0.010 ± 0.013	0.06 ± 0.08	**-0.052 ± 0.016**	**-0.26 ± 0.08**	**-0.19 ± 0.11**
Lauder	4.2	0.005 ± 0.013	0.03 ± 0.08	**-0.054 ± 0.016**	**-0.27 ± 0.08**	**-0.22 ± 0.11**

Values are weighted averages of 8 pressure levels ± 95% CI

Downward trends in FP–MLS at Boulder, Lindenberg and Lauder since ~2010 are similar to the long-term increasing trends over Boulder

Period 2 changes in FP–MLS are 6-9% of SWV mixing ratios

Summary from 30 km Rocky Mountains

Significant divergences between MLS and FPH/CFH at Boulder, Lindenberg and Lauder since ~2010

Most Per. 2 trends at Hilo & San José are not significant

Period 2 trends in FP–MLS @ BLD, LIN & LDR

Stratospheric average is –0.06 ppm yr^{-1} (-1.3% yr^{-1})

Stratospheric avg Per. 2 Δ(FP–MLS) is –0.3 ppm (-7%)

Results are very similar for MLS versions 3.3 and 4.2

Photo by Patrick Cullis, NOAA