Implications of the Continued Increase in Atmospheric Methane Burden

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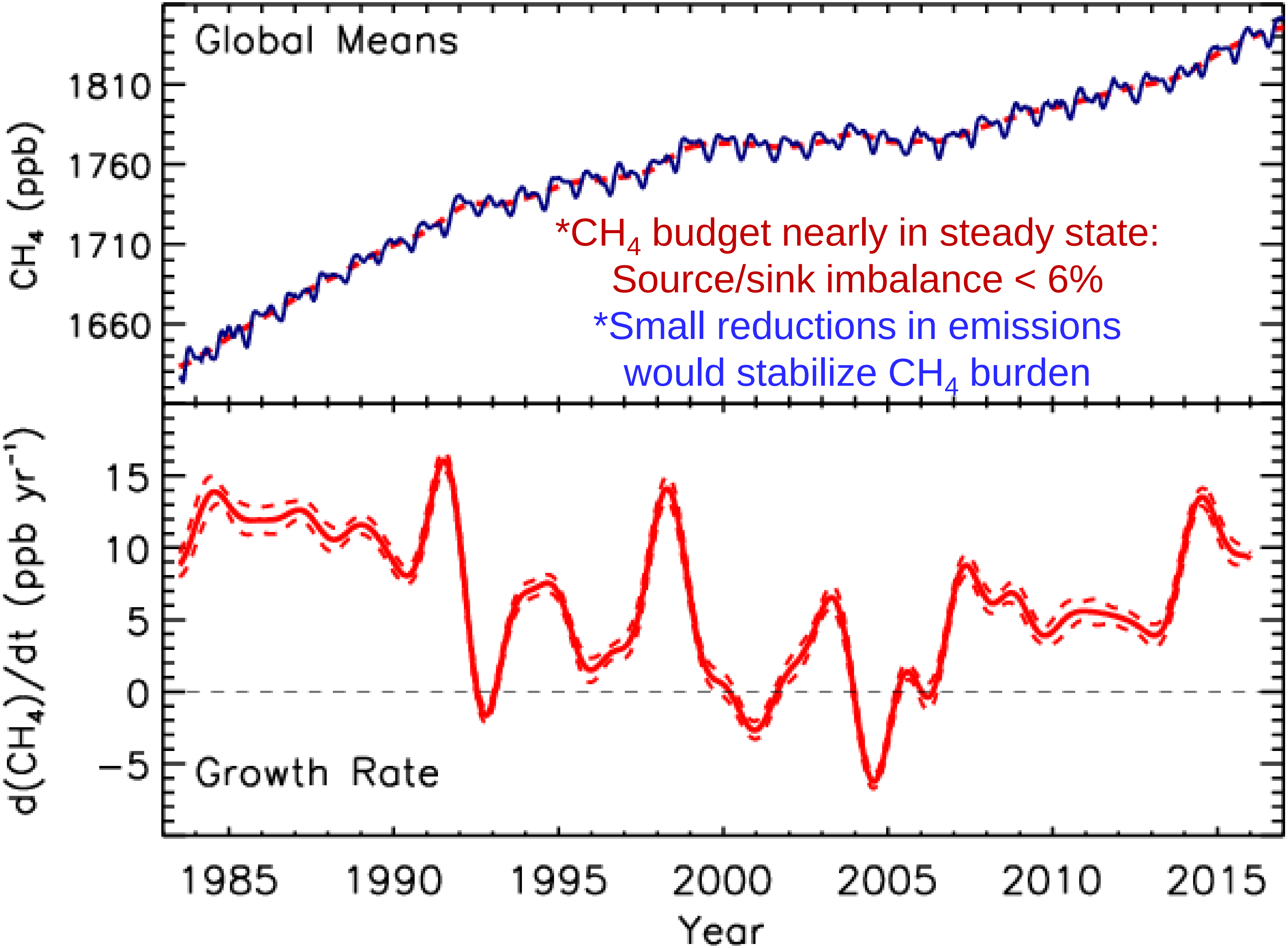
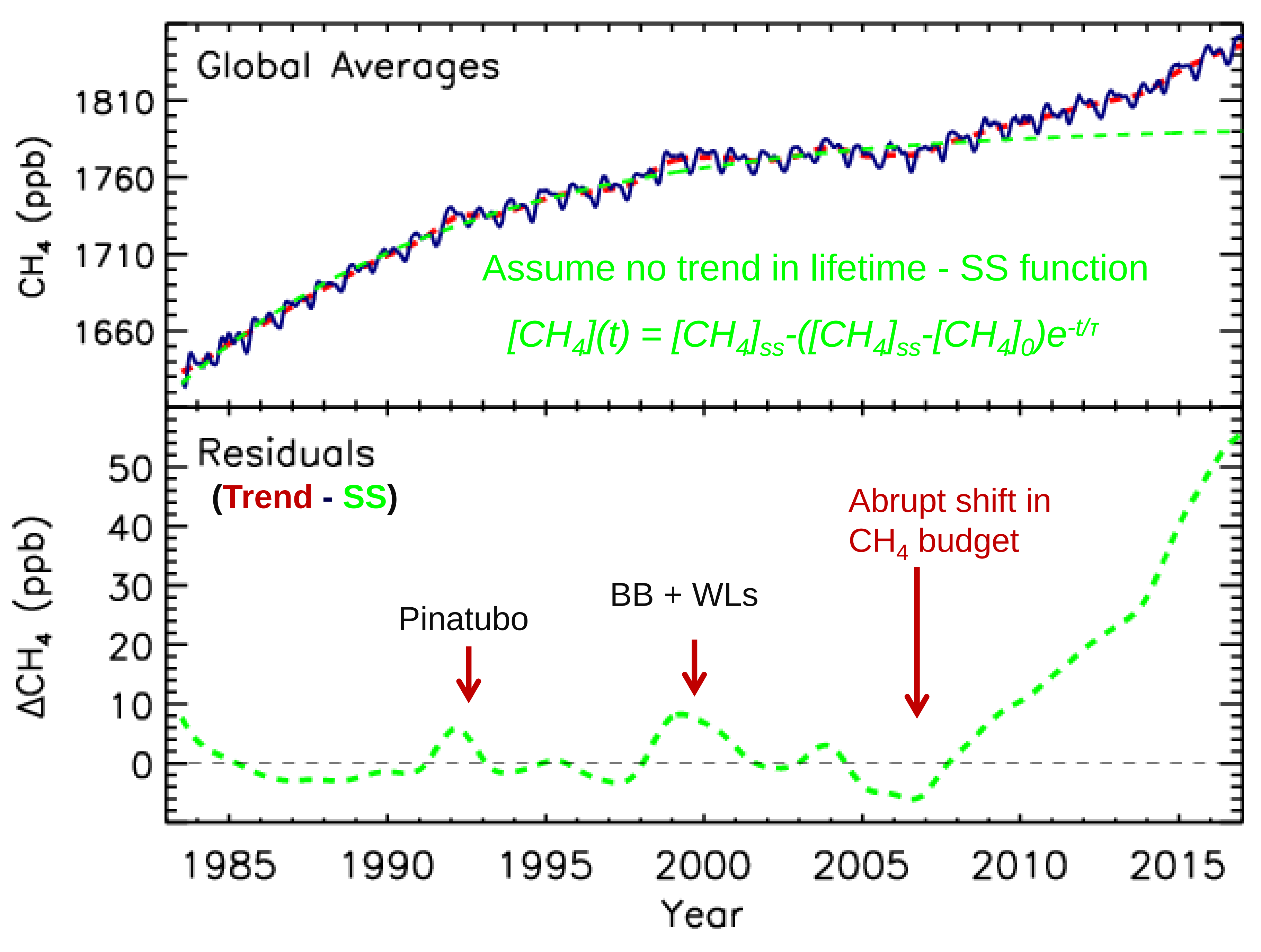
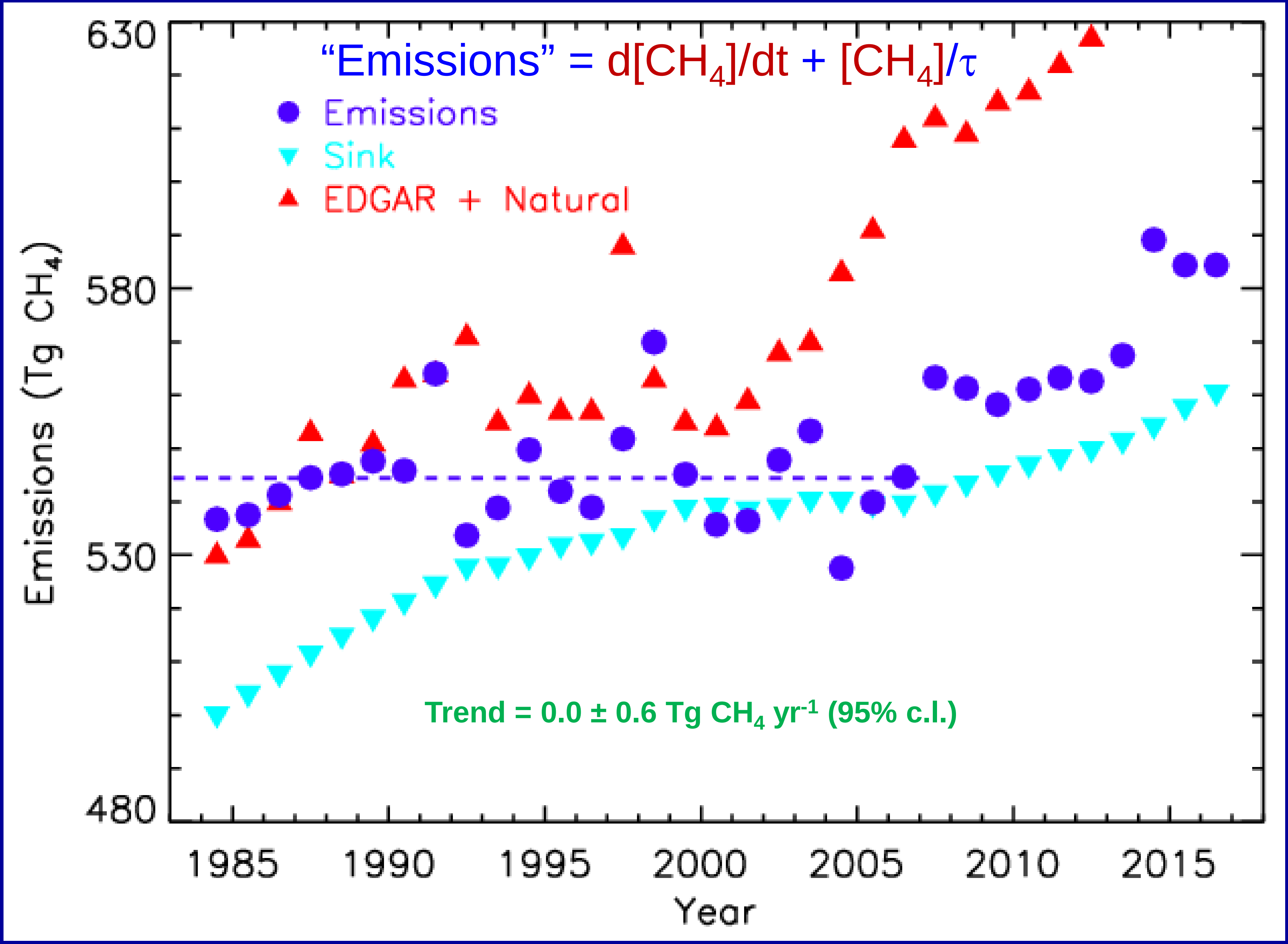
[1]NOAA ESRL GMD, [2]CIRES



Global Means
1810
1760
1710
1660
CH4 (ppb)
*CH4 budget nearly in steady state:
Source/sink imbalance < 6%
*Small reductions in emissions
would stabilize CH4 burden
15
10
5
0
−5
d(CH4)/dt (ppb yr-1)
Growth Rate
1985
1990
1995
2000
2005
2010
2015
Year



Global Averages
Assume no trend in lifetime - SS function
$[CH_4](t) = [CH_4]_{ss}-([CH_4]_{ss}-[CH_4]_0)e^{-t/\tau}$
Residuals
(Trend - SS)
Abrupt shift in
CH_4 budget
BB + WLs
Pinatubo
CH_4 (ppb)
ΔCH_4 (ppb)
1810
1760
1710
1660
50
40
30
20
10
0
1985
1990
1995
2000
2005
2010
2015
Year

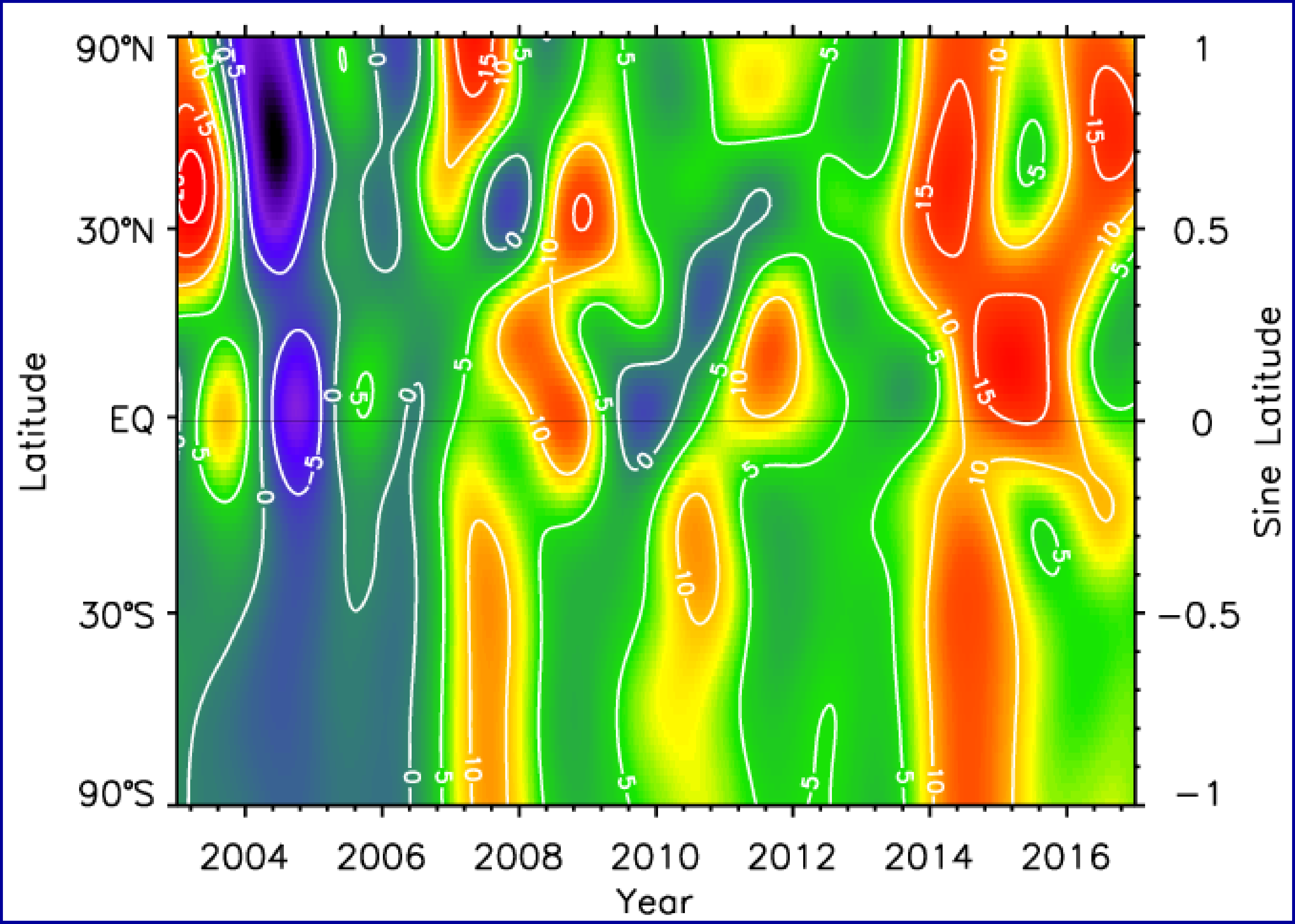


“Emissions” = d[CH4]/dt + [CH4]/τ
Emissions
Sink
EDGAR + Natural
Trend = 0.0 ± 0.6 Tg CH4 yr-1 (95% c.l.)
Emissions (Tg CH4)
630
580
530
480
1985
1990
1995
2000
2005
2010
2015
Year

What we know from atmospheric observations:

- The increase since 2007 started abruptly
- GR suggests tropics are important
- $\delta^{13}C(CH_4)$ is decreasing
  - Constrains possible drivers
- Not likely increased FF emissions
- Not likely increased Arctic emissions

Spatial Patterns



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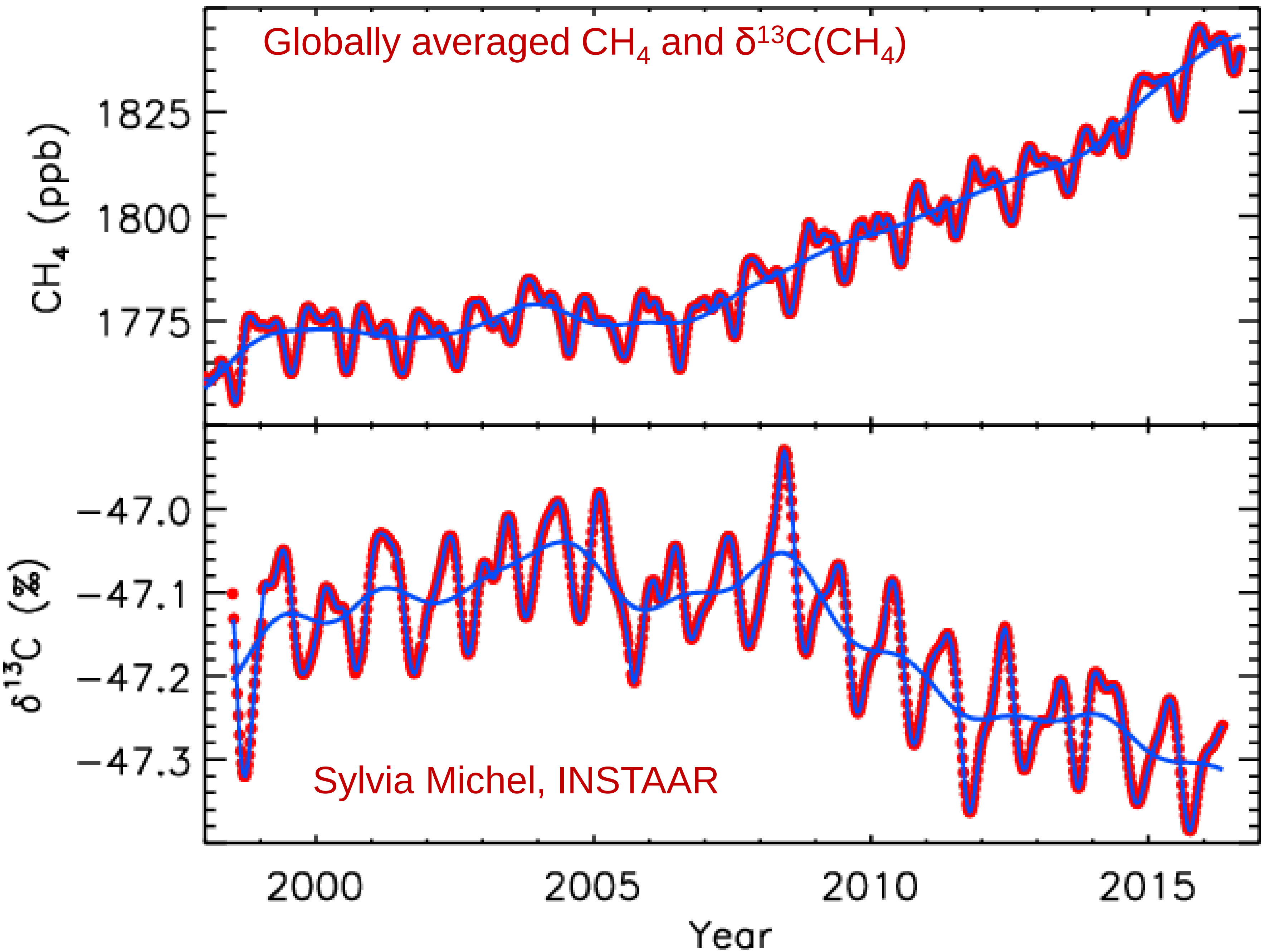
Globally averaged CH_4 and $\delta^{13}C(CH_4)$
1825
1800
1775
CH_4 (ppb)
−47.0
−47.1
−47.2
−47.3
$\delta^{13}C$ (‰)
Sylvia Michel, INSTAAR
2000
2005
2010
2015
Year

What does $\delta^{13}C$ tell us?

- Schaefer et al., Nature, 2016
  - Increased microbial emissions outside Arctic
  - More likely agricultural sources than wetlands
- Nisbet et al., GBC, 2016
  - Increased microbial emissions in tropics
  - Wetlands and ag sources could contribute
    - Role for meteorology
  - Unlikely that changing lifetime contributed

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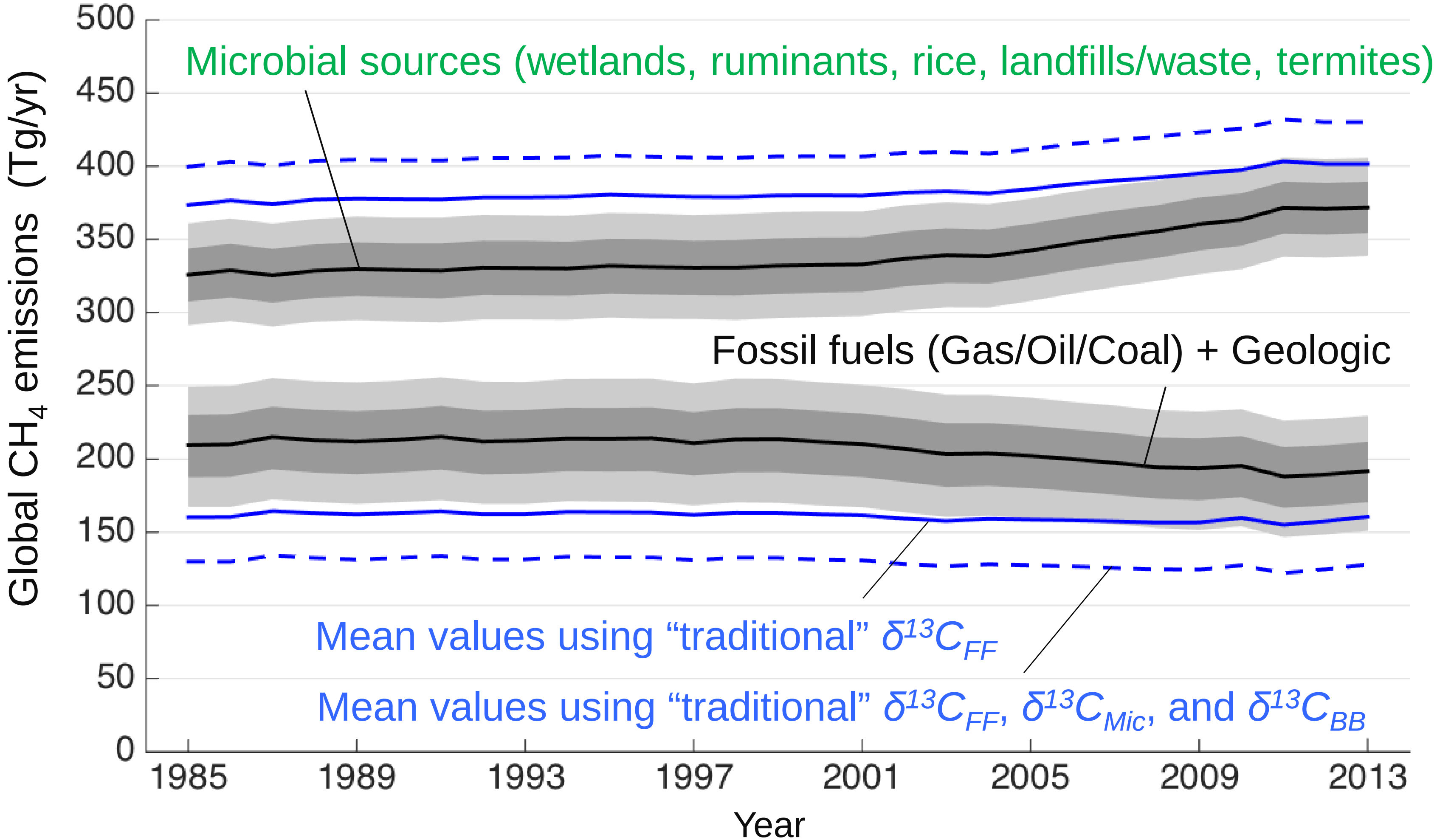
Fossil CH_4 emissions not increasing

(Schwietzke et al., Nature, 538, 88-91, 2016)



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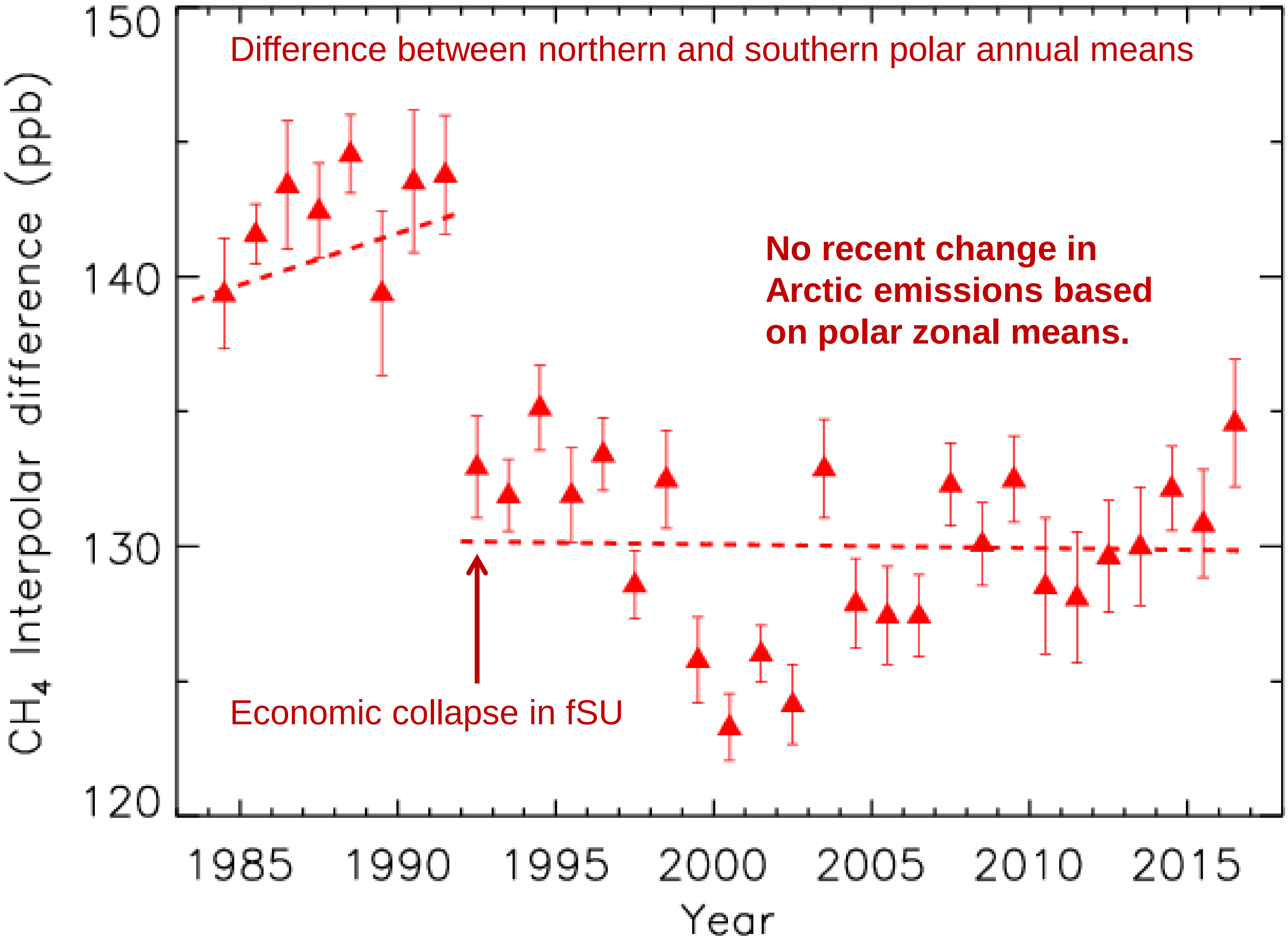
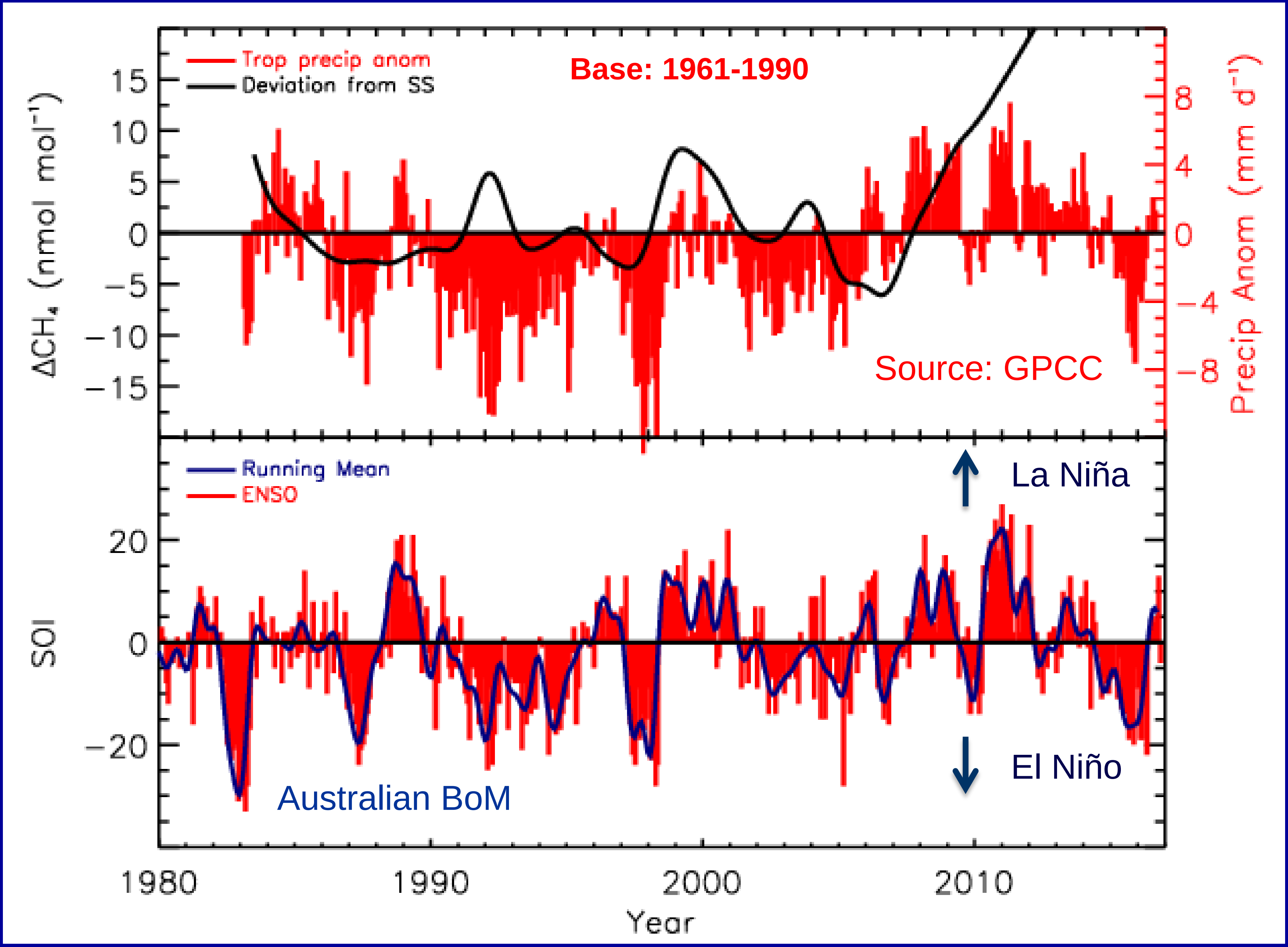
Arctic permafrost and clathrates?

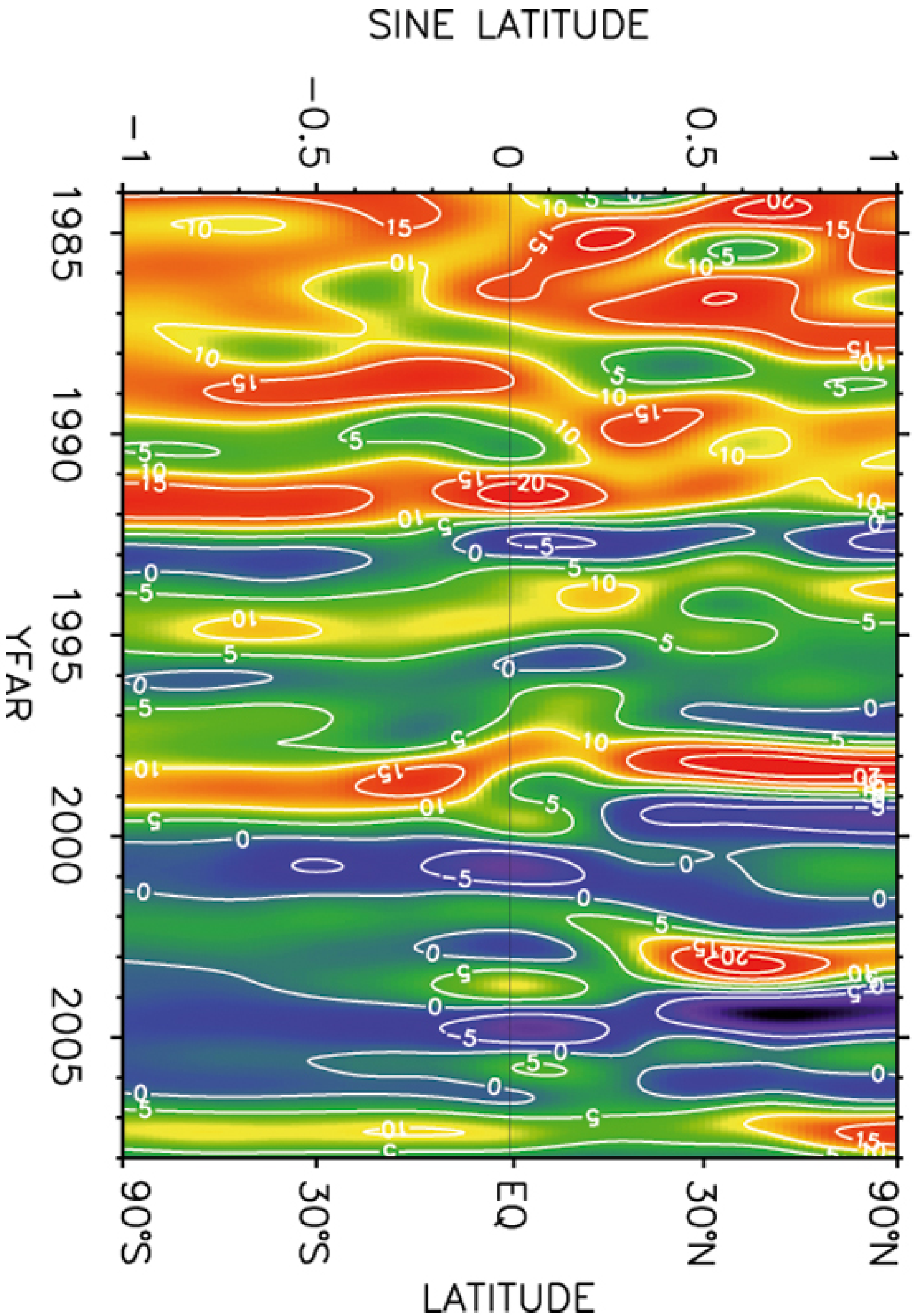


ENSO Phase: Precipitation

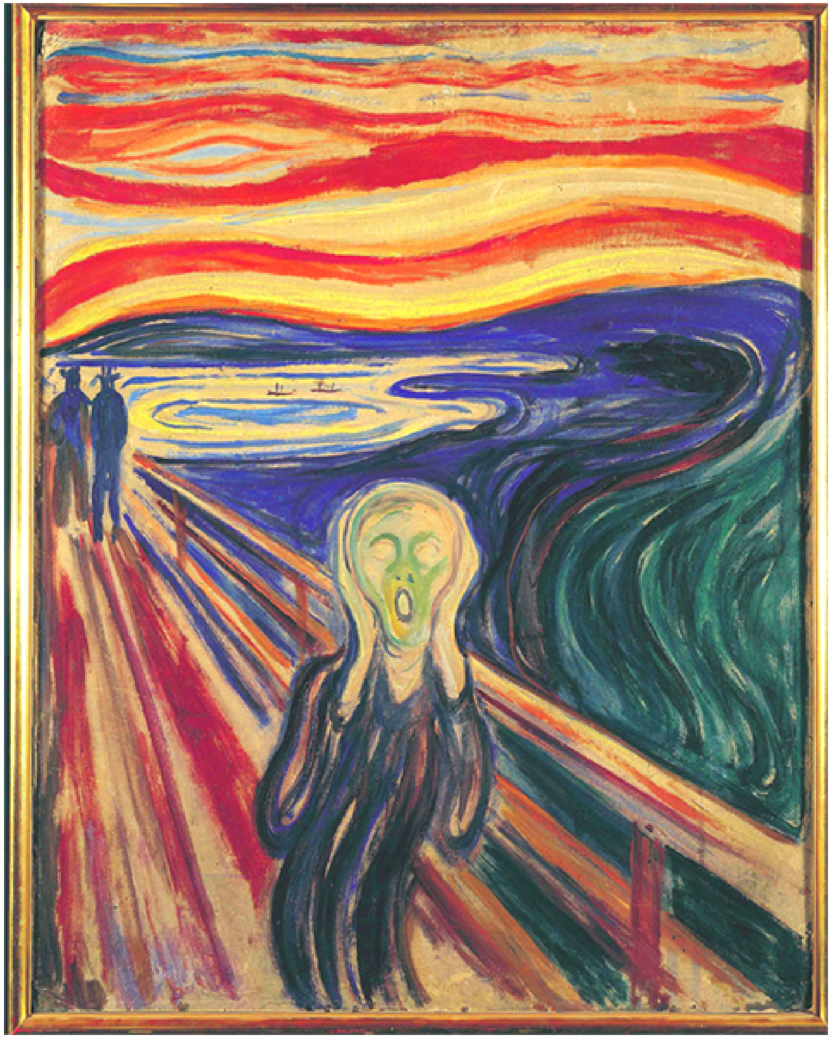


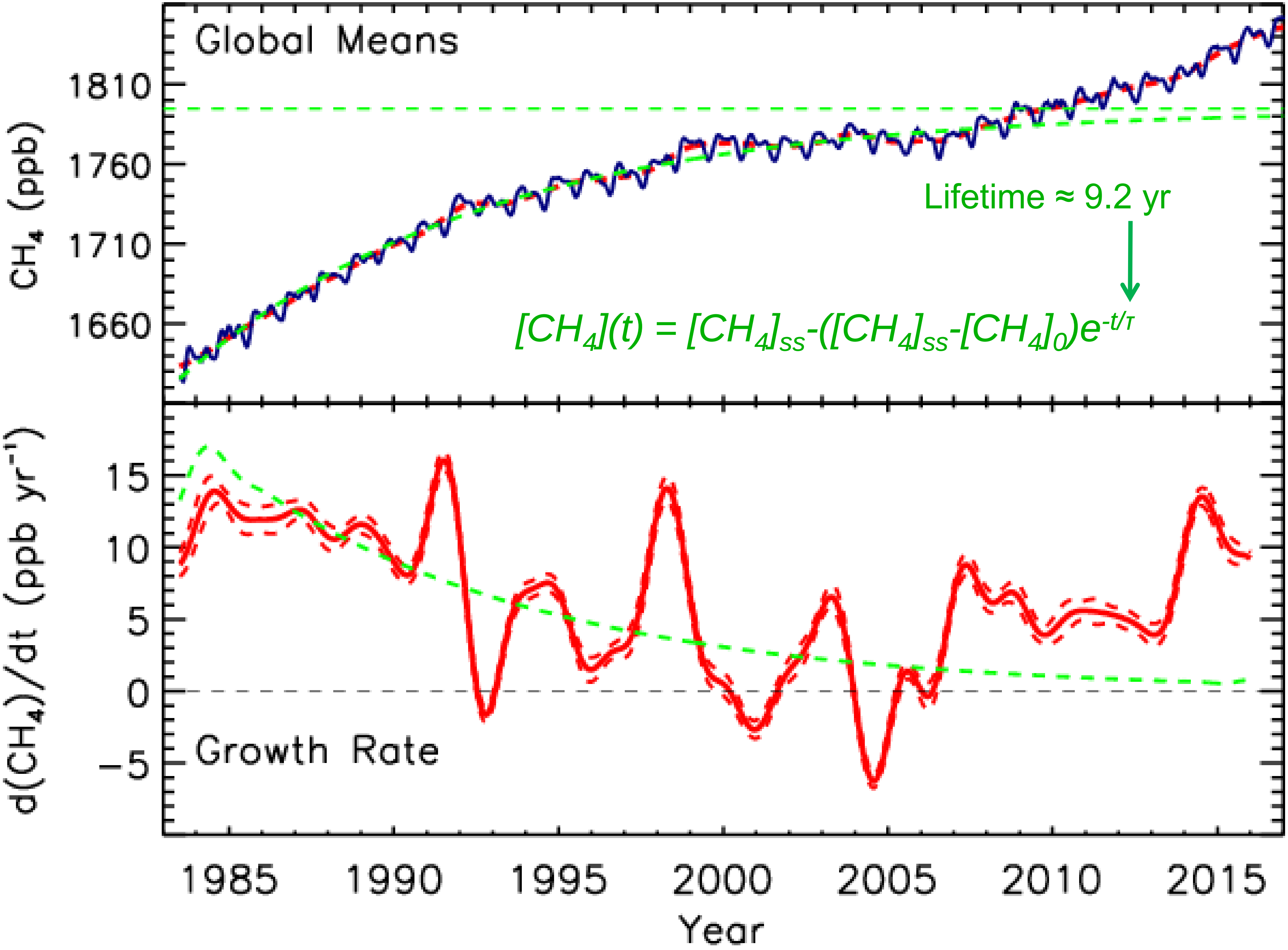
Conclusions

- Increased CH_4 GR starting in 2007
  - Initiated by tropical wetlands
    - Consistent with: abrupt timing, ENSO, spatial patterns, and observed $\delta^{13}C$ (CH_4)
  - Sustained by increased agricultural emissions
  - Potential contribution from changing lifetime
- Potential Climate Feedback
  - Connection with meteorology
  - Should we be concerned?



Source: Carl Brenninkmeijer

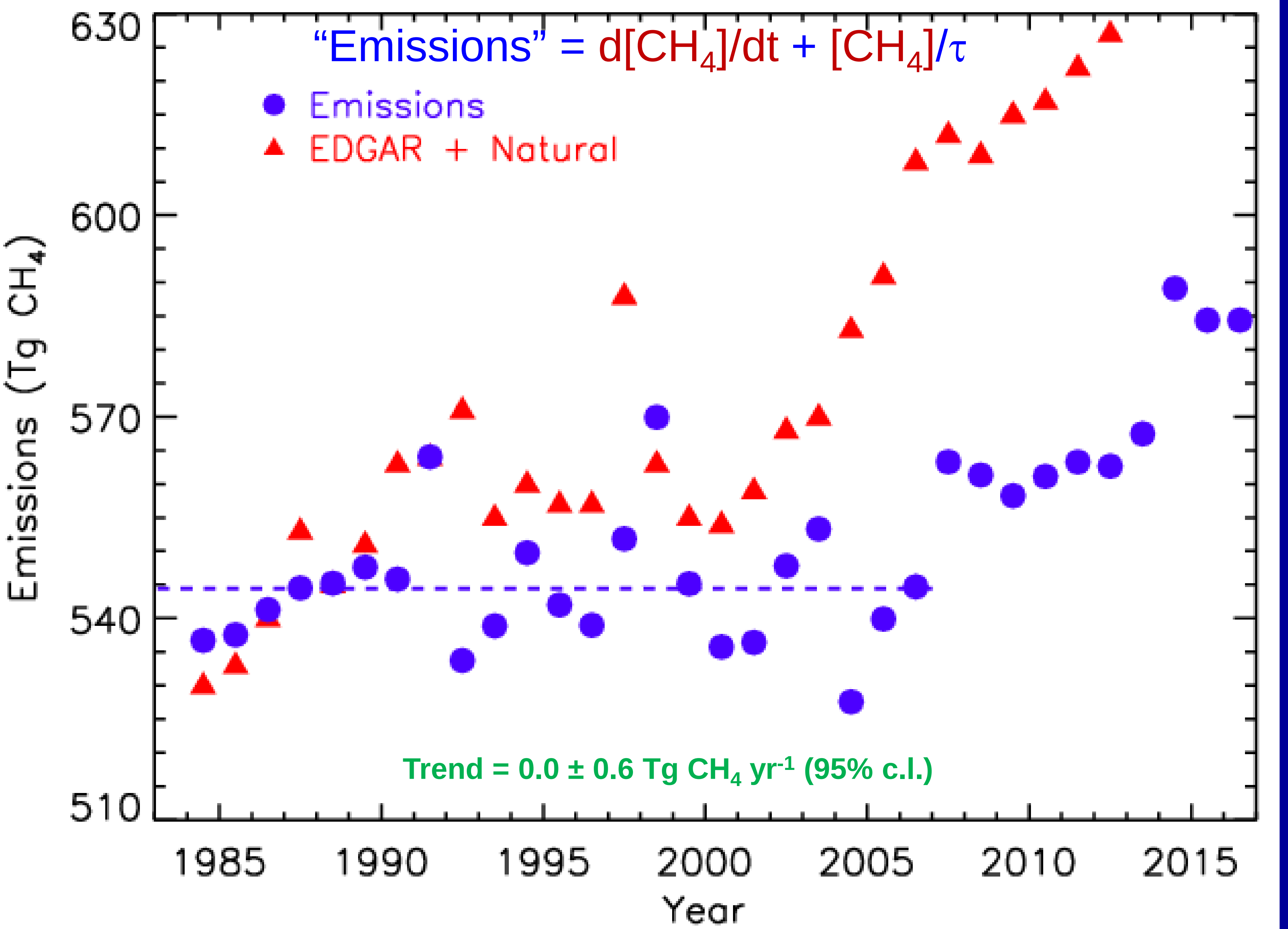




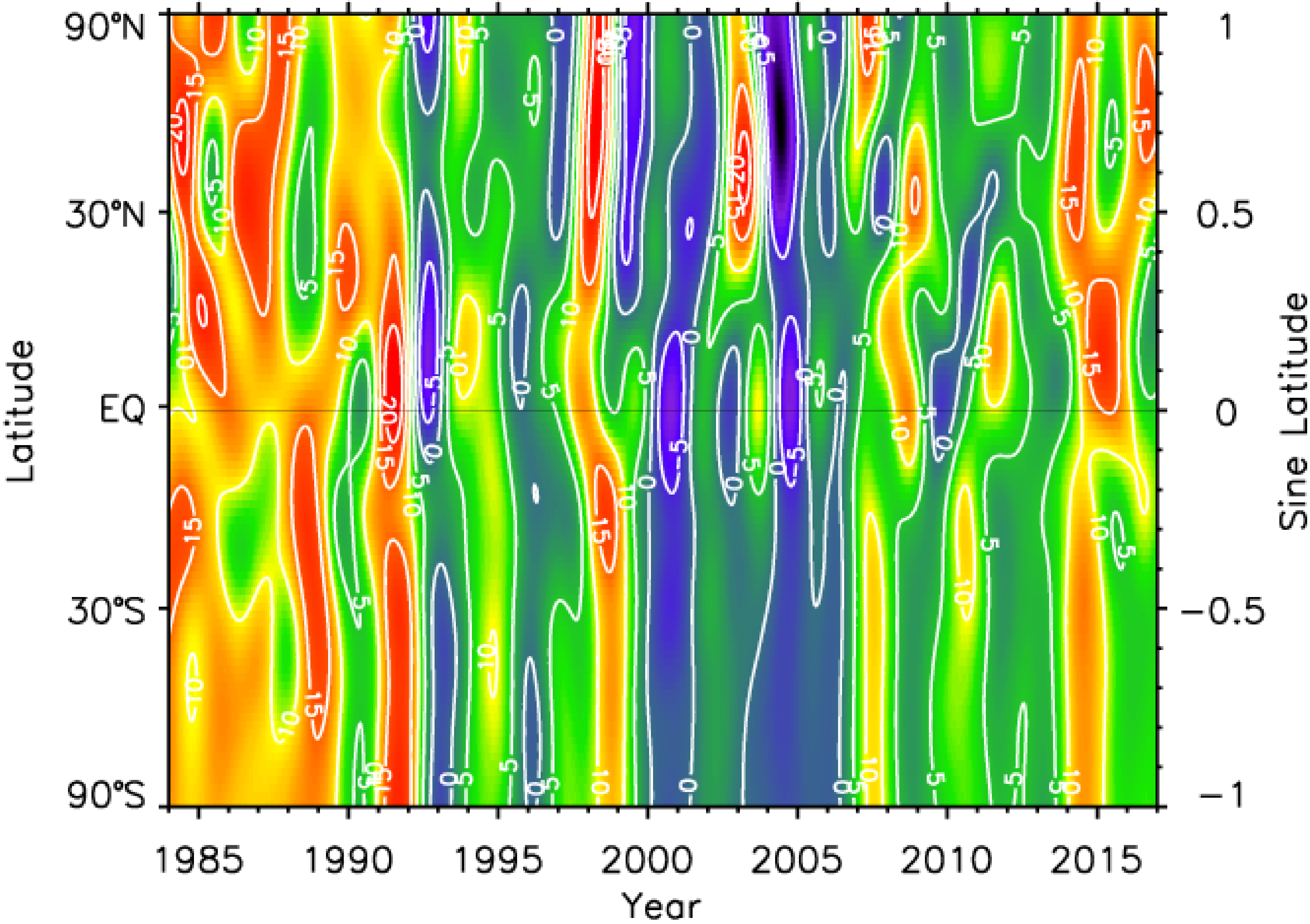
Global Means
CH4 (ppb)
1810
1760
1710
1660
Lifetime ≈ 9.2 yr
[CH4](t) = [CH4]ss-([CH4]ss-[CH4]0)e-t/τ
d(CH4)/dt (ppb yr-1)
15
10
5
0
−5
Growth Rate
1985
1990
1995
2000
2005
2010
2015
Year

Why is CH_4 Important?

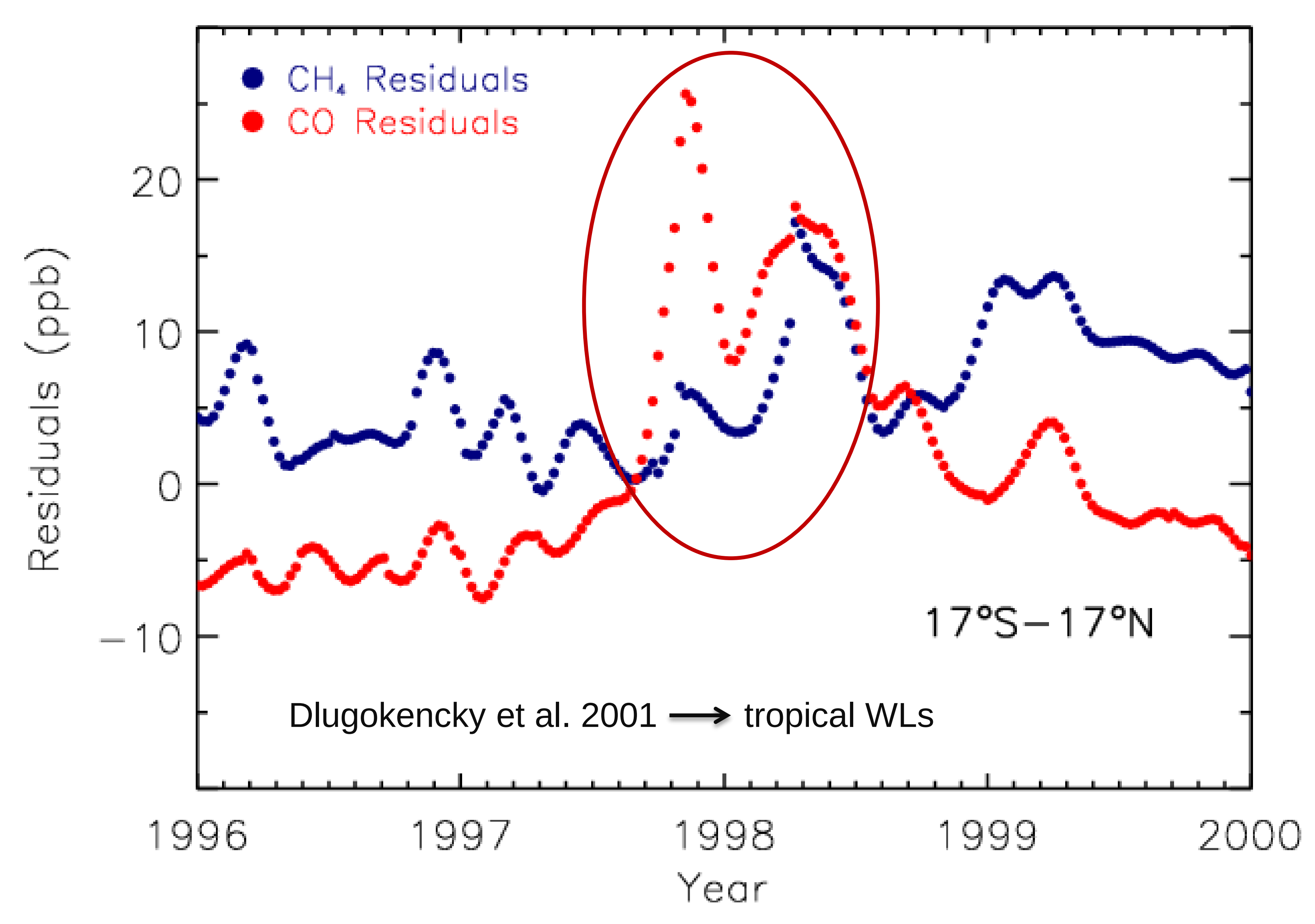
- 0.51* W m^{-2} RF in 2016 (CO_2: 1.99 W m^{-2})
  - ΔRF = 25 mW m^{-2} since 2006
- ~0.3 W m^{-2} indirect RF (O_3 and H_2O)
- Drivers behind current trends are poorly understood
  - Emissions? If so, which sources?
  - Sink? If so, by what mechanism?

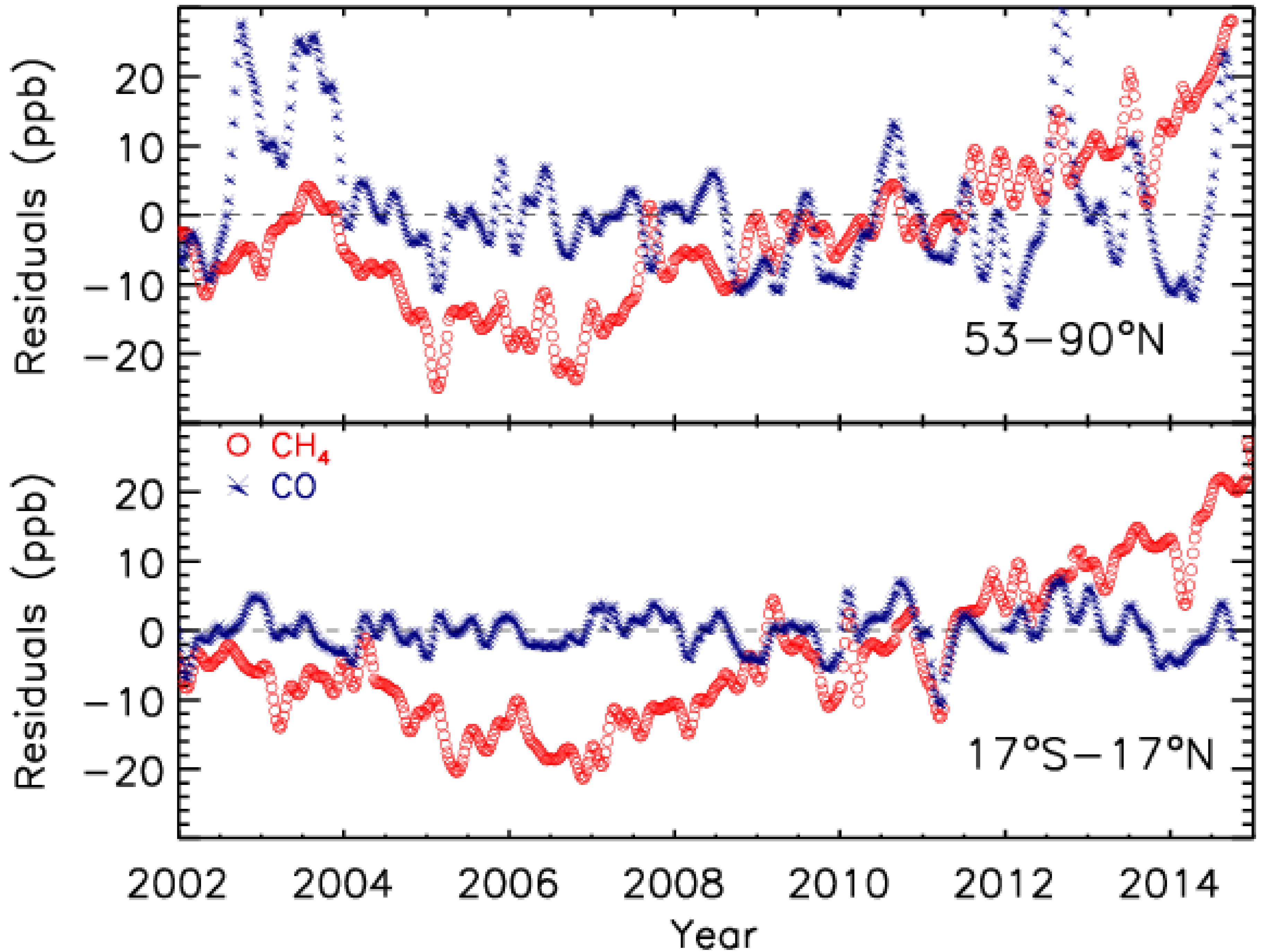


"Emissions" = d[CH4]/dt + [CH4]/τ
Emissions
EDGAR + Natural
Trend = 0.0 ± 0.6 Tg CH4 yr-1 (95% c.l.)
630
600
570
540
510
Emissions (Tg CH4)
1985
1990
1995
2000
2005
2010
2015
Year



90°N
30°N
EQ
30°S
90°S
Latitude
1
0.5
0
−0.5
−1
Sine Latitude
1985
1990
1995
2000
2005
2010
2015
Year


CH4 Residuals
CO Residuals
Residuals (ppb)
20
10
0
−10
17°S−17°N
Dlugokencky et al. 2001 ⟶ tropical WLs
1996
1997
1998
1999
2000
Year



Residuals (ppb)
20
10
0
−10
−20
53−90°N
CH4
CO
17°S−17°N
2002
2004
2006
2008
2010
2012
2014
Year

Global CH_4 Budget by Source

Source	Bousquet (Tg/yr)	IPCC Range (Tg/yr)
Anthropogenic		
Energy	110±13	74-106
Enteric fermentation	90±14	76-92
Rice agriculture	31±5	31-112
Biomass burning	50±8	14-88
Waste	55±11	35-69
Natural		
Wetlands	147±15	100-231
Termites	23±4	20-29
Oceans	19±6	4-15
Total	**525±8**	**503-610**

Sinks	Bousquet (Tg/yr)	IPCC (Tg/yr)
Troposphere	448±1	428-511
Stratosphere	37±1	30-45
Soil	21±3	26-34
Total	**506**	**492-581**

Bousquet et al., 2006, *Nature*, **443**, 439-443, doi:10.1038/nature05132.