Tracking Changing Arctic Methane Emissions

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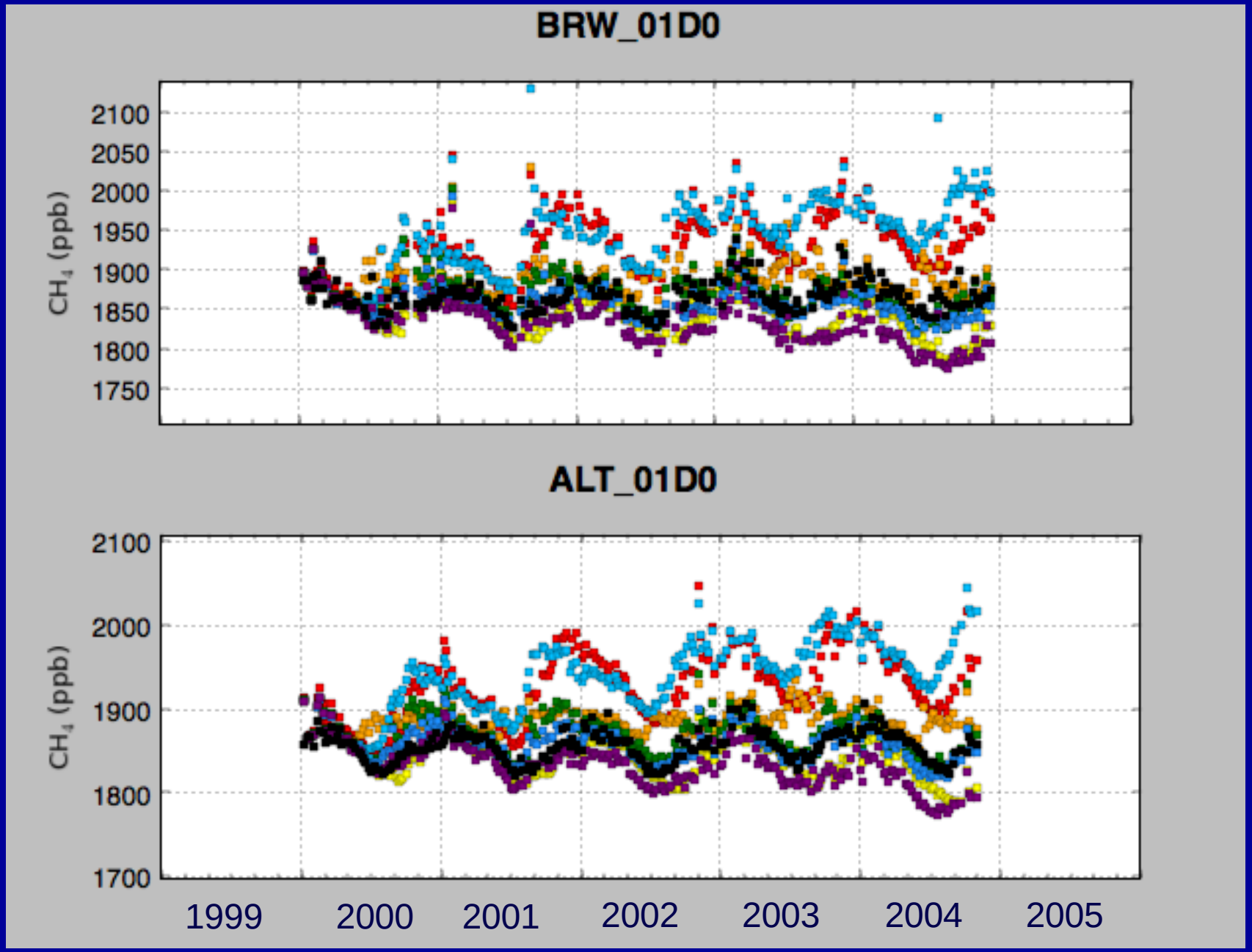
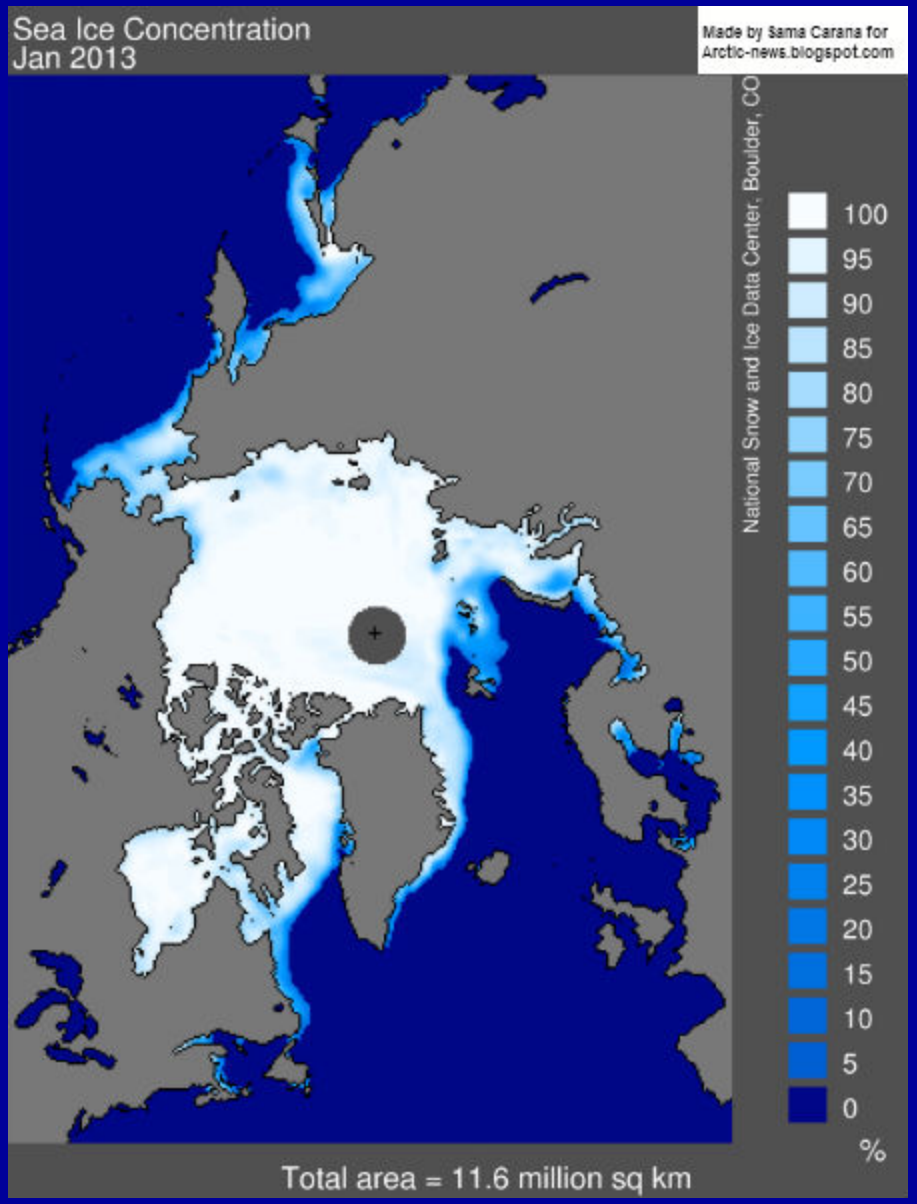
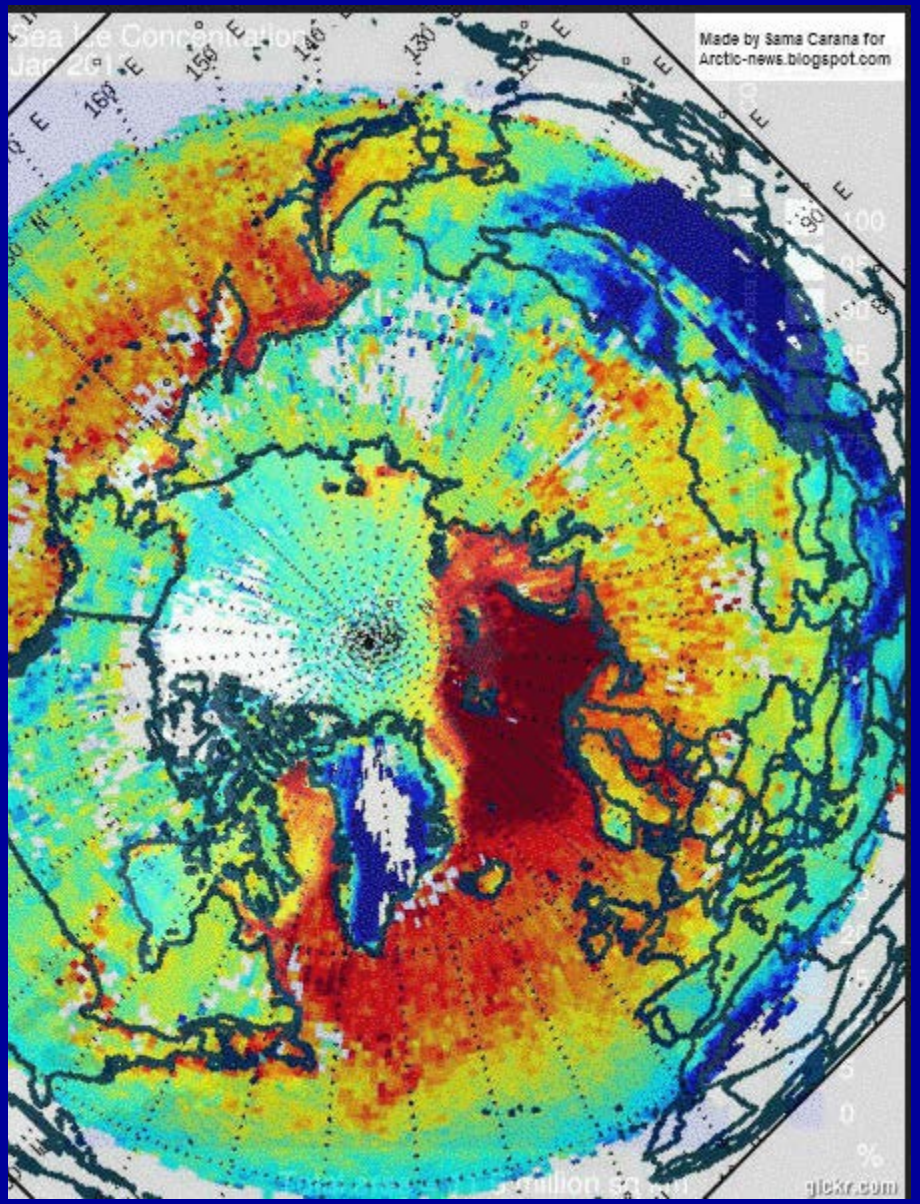
Climate and Arctic CH_4 processes

- Rate of T increase is 3X global average
  - Wetland emissions sensitive to soil T
  - $E_T = E_{T_0} Q_{10}^{(T-T_0/10)}$ where $Q_{10} = E_{T+10}/E_T$
  - Typical WL Q_{10} = 7: ~50% ↑ E for 2°C ↑ soil T.
- ~1000 Pg C in top 3 m permafrost soils
  - Melting PF expands wetland area and releases carbon
- 30 to 170 Pg CH_4 in Arctic Ocean hydrates
- Want to predict ΔE for Δclimate
- Science sensationalized by some

Wetland process models vs observation







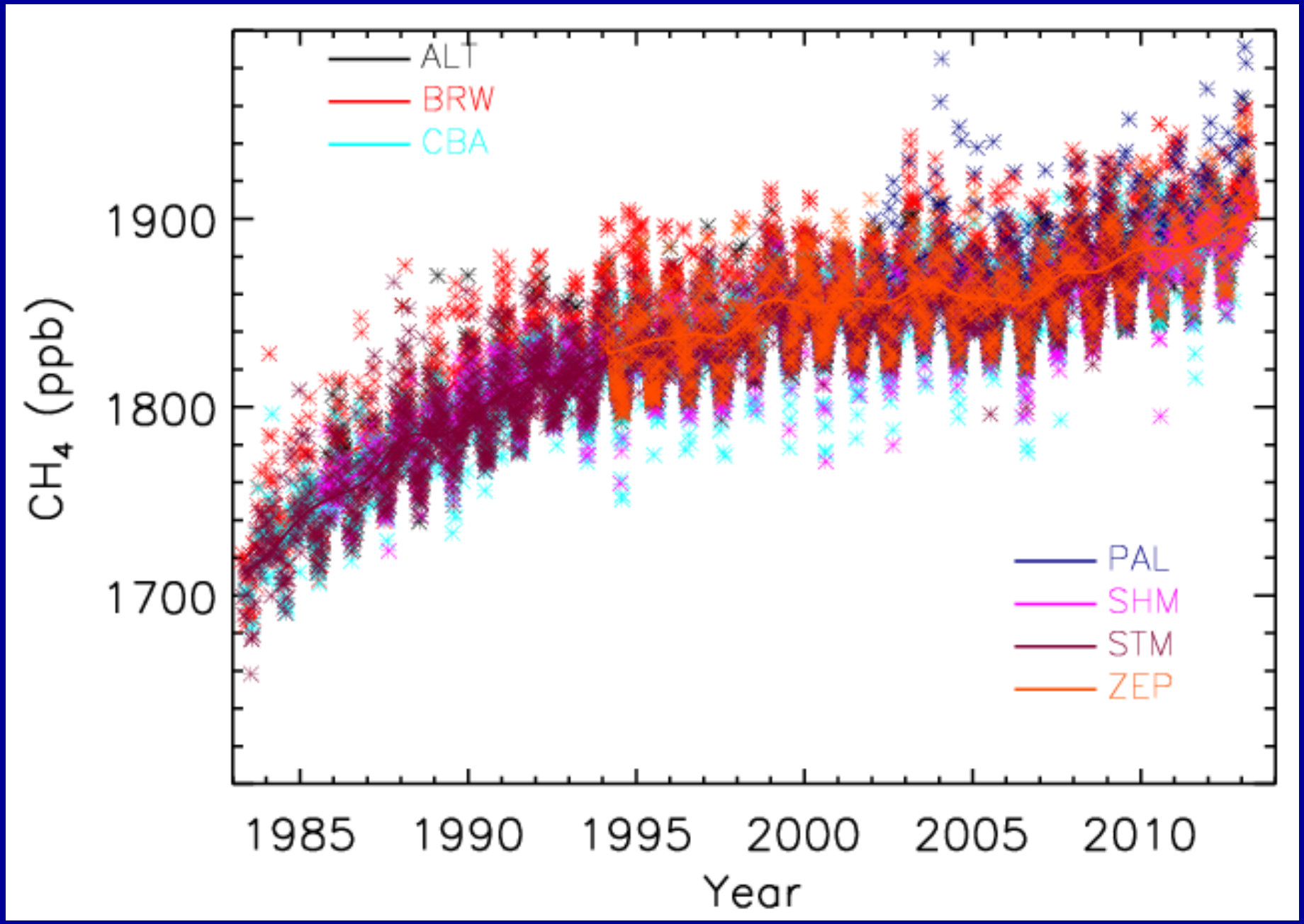
NSIDC: Sea Ice Loss (%)

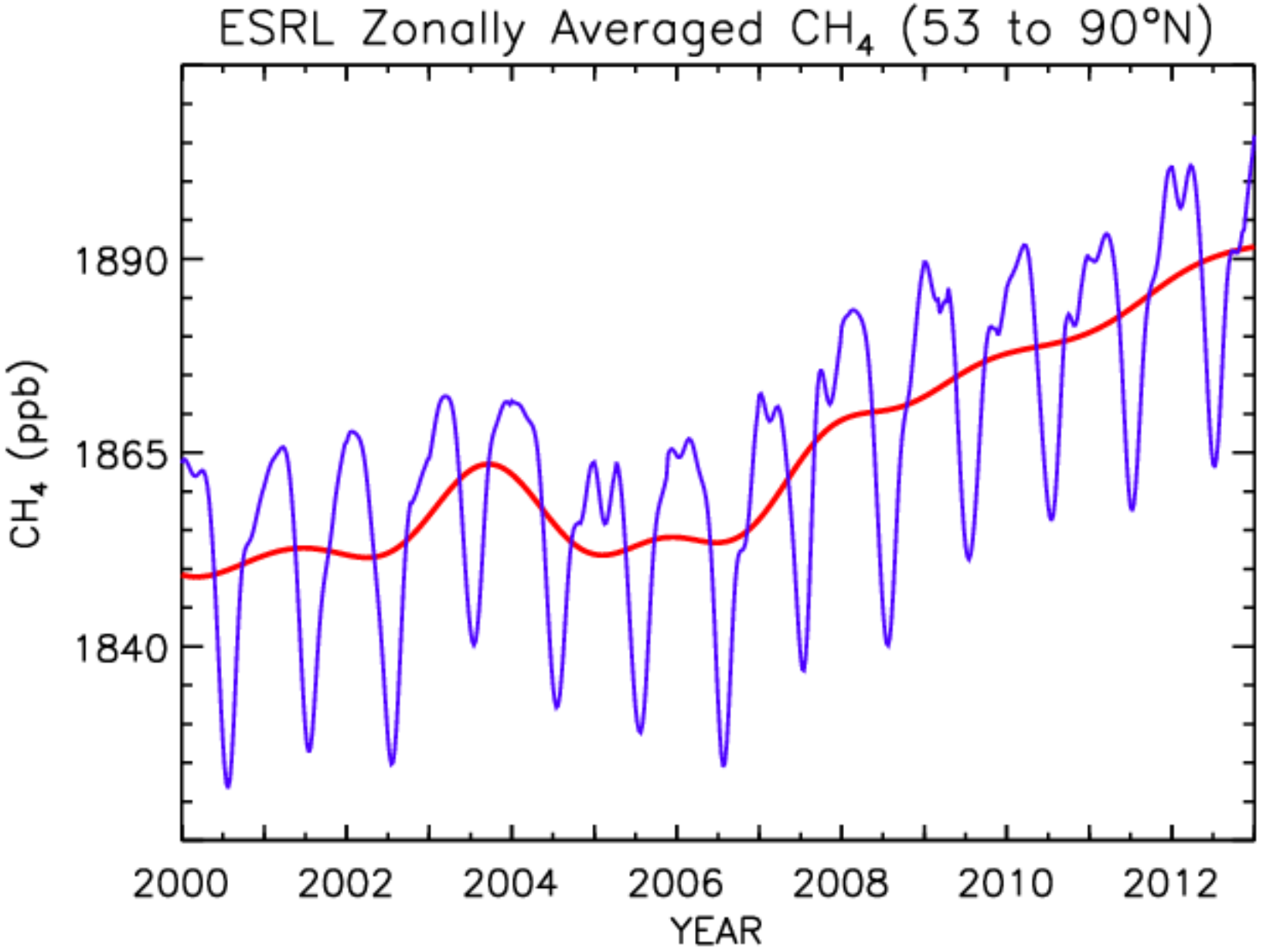
1780

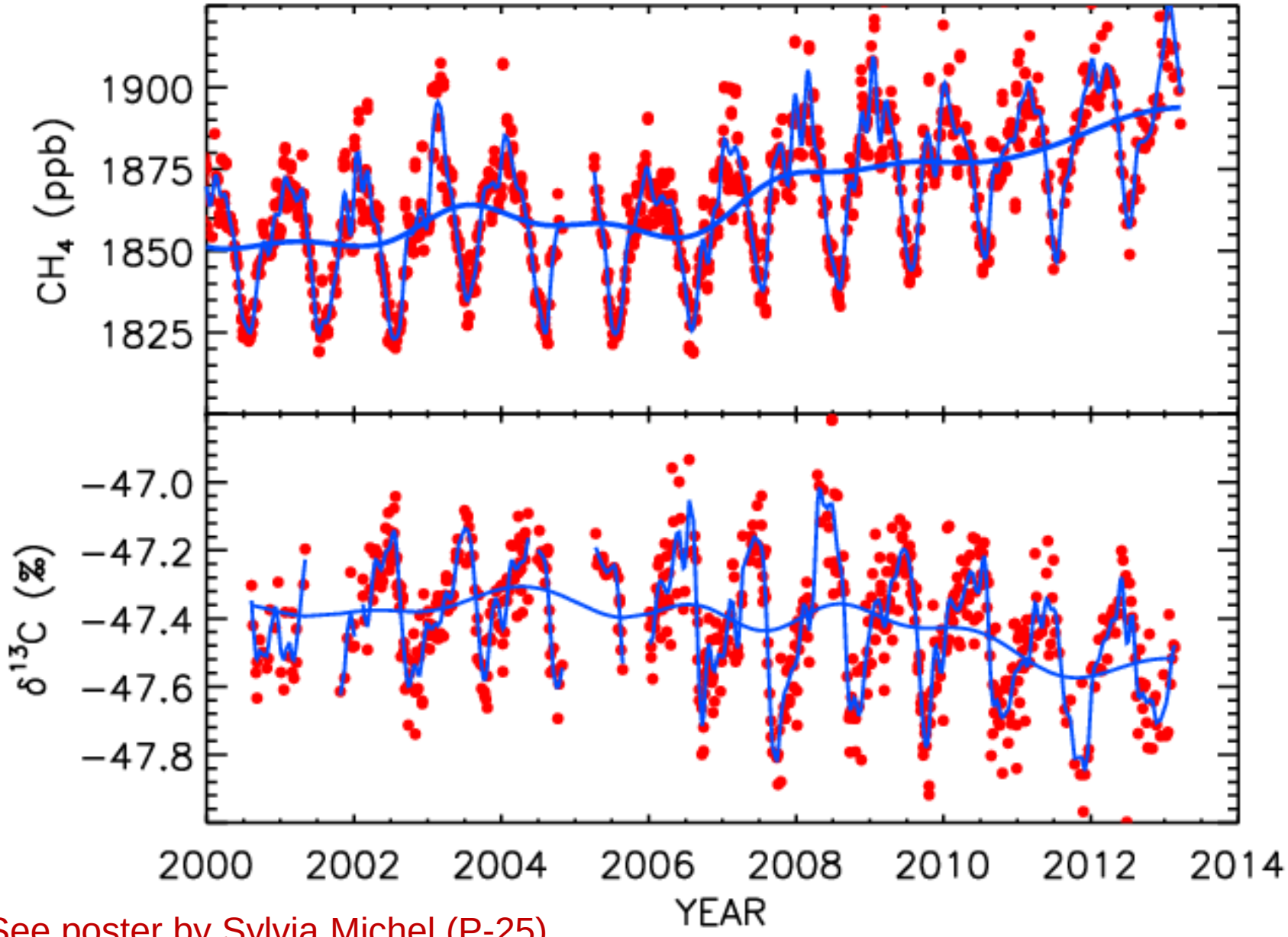
1920

AIRS CH_4: ppb

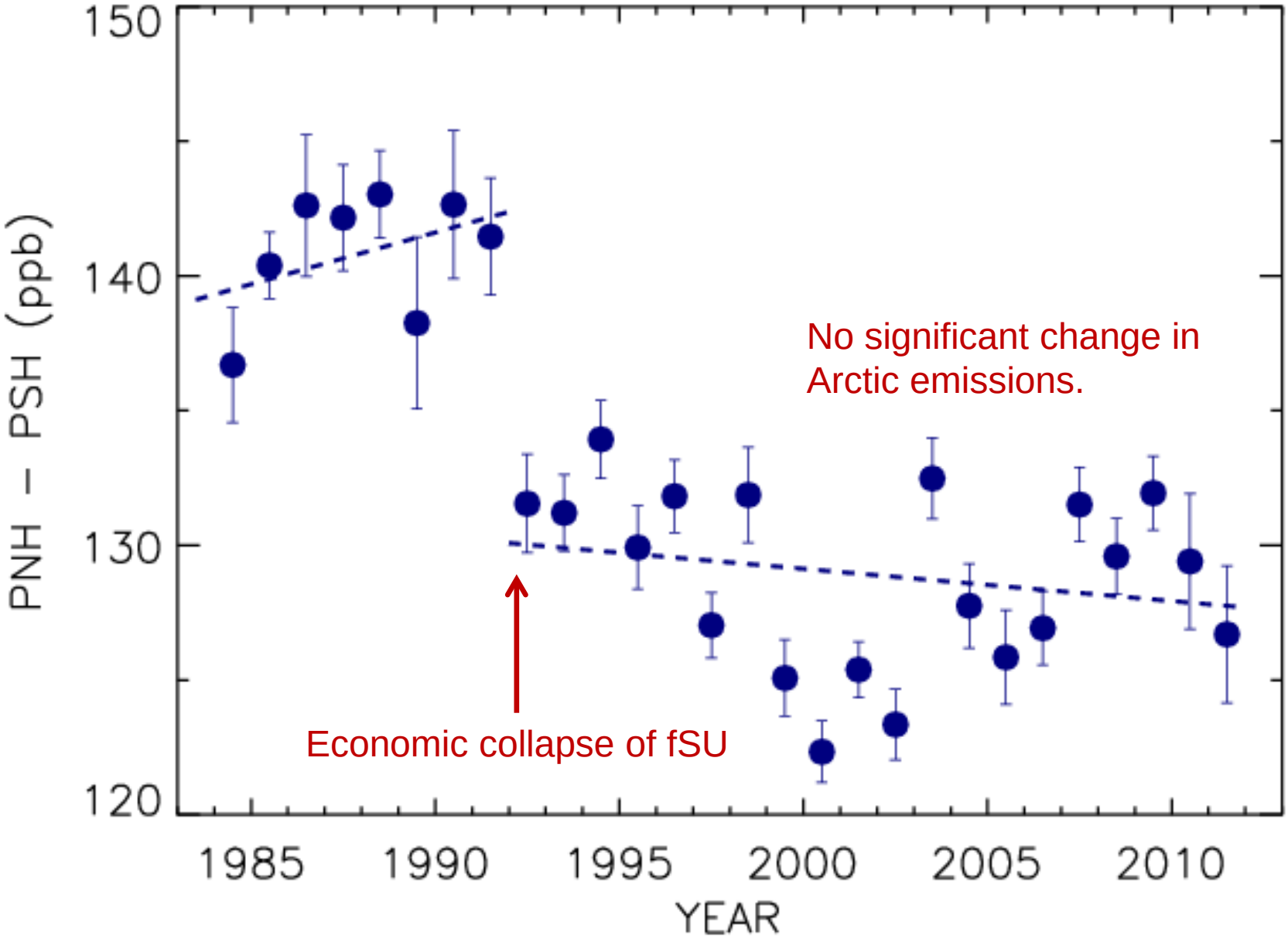
http://arctic-news.blogspot.co.uk/2013/02/...


ALT
BRW
CBA
PAL
SHM
STM
ZEP
1900
1800
1700
CH4 (ppb)
1985
1990
1995
2000
2005
2010
Year

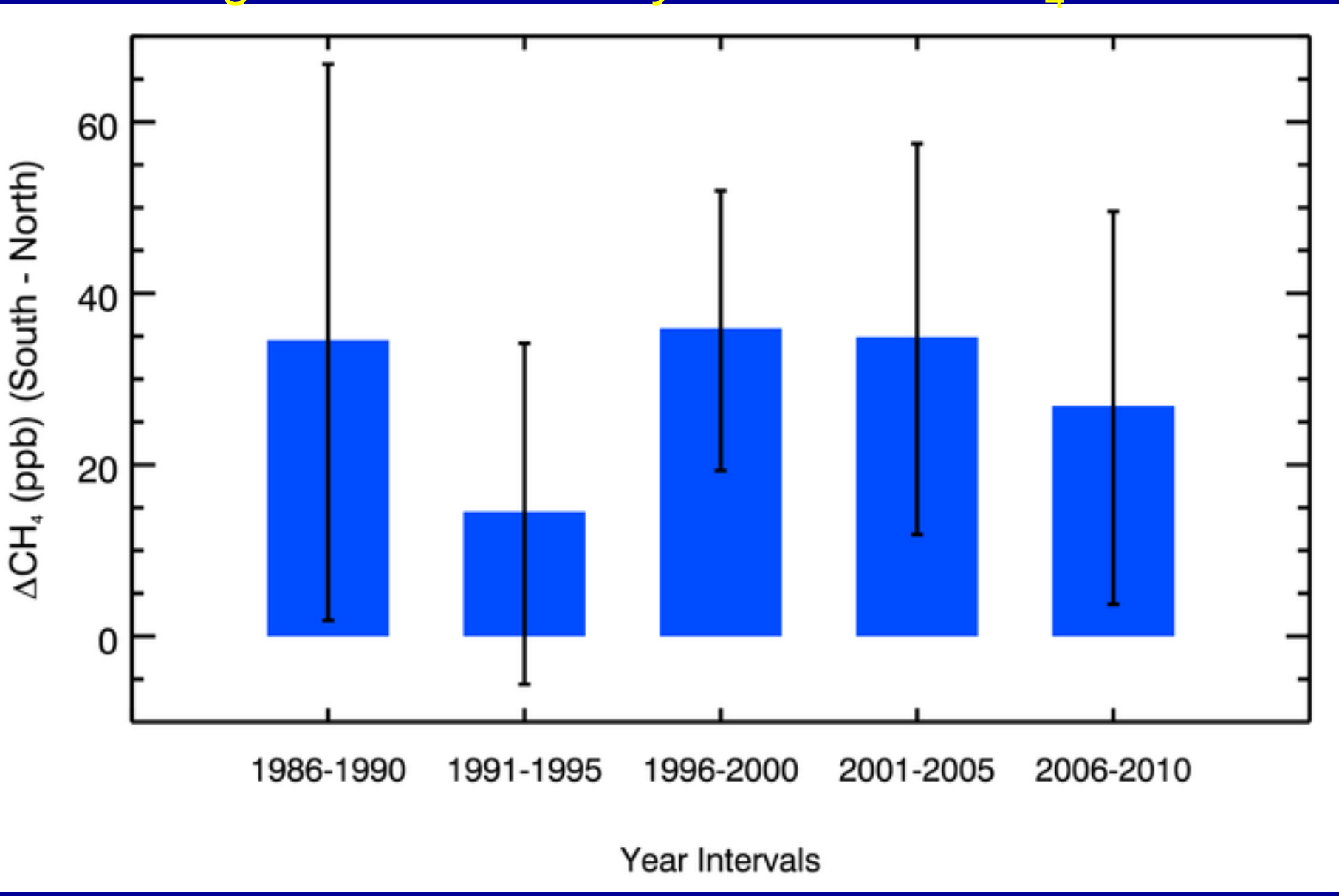

ESRL Zonally Averaged CH4 (53 to 90°N)
CH4 (ppb)
1890
1865
1840
2000
2002
2004
2006
2008
2010
2012
YEAR



*See poster by Sylvia Michel (P-25)


150
140
130
120
PNH – PSH (ppb)
1985
1990
1995
2000
2005
2010
YEAR
No significant change in
Arctic emissions.
Economic collapse of fSU

Regional scale: Analysis of BRW CH_4 data

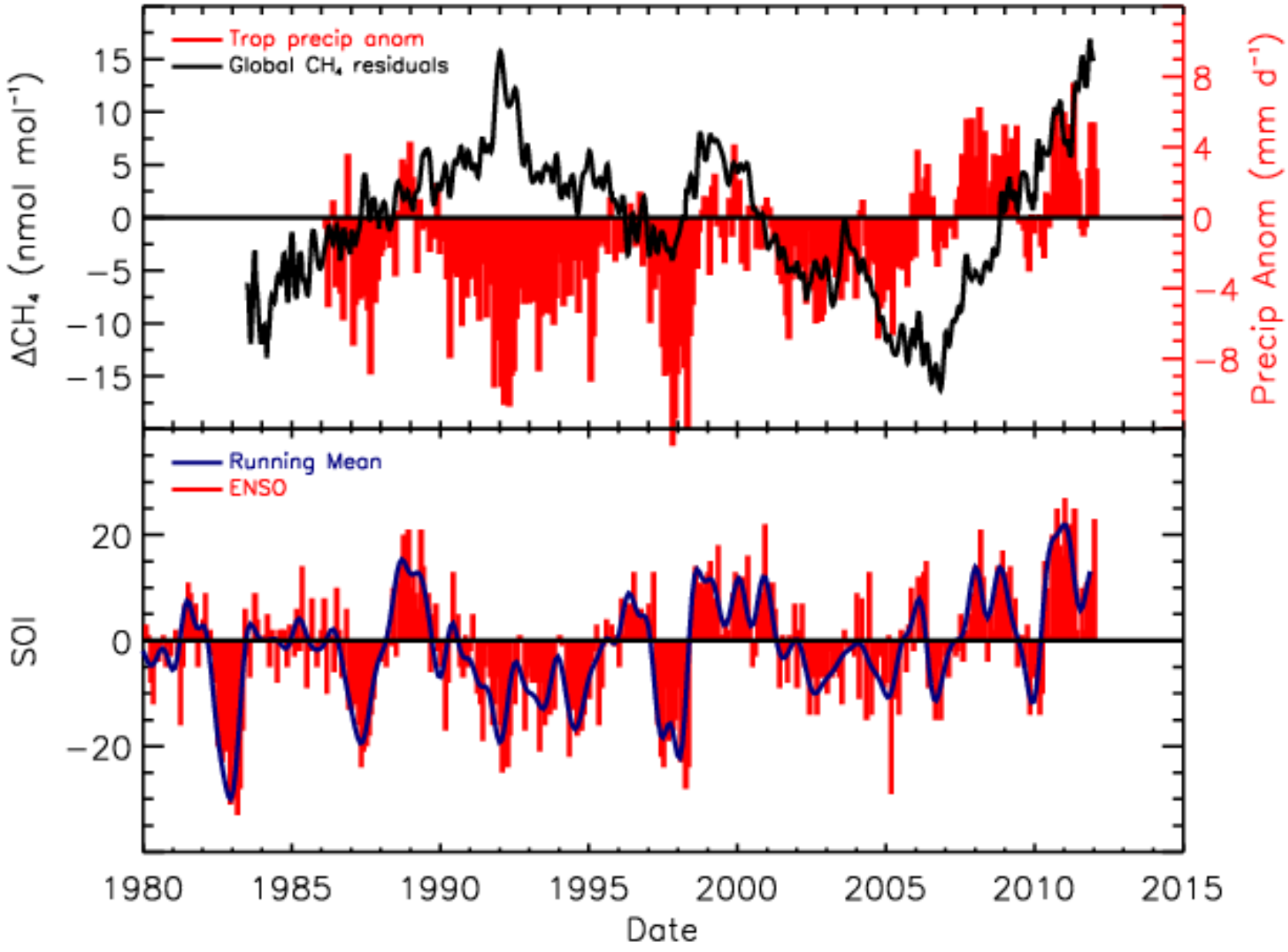


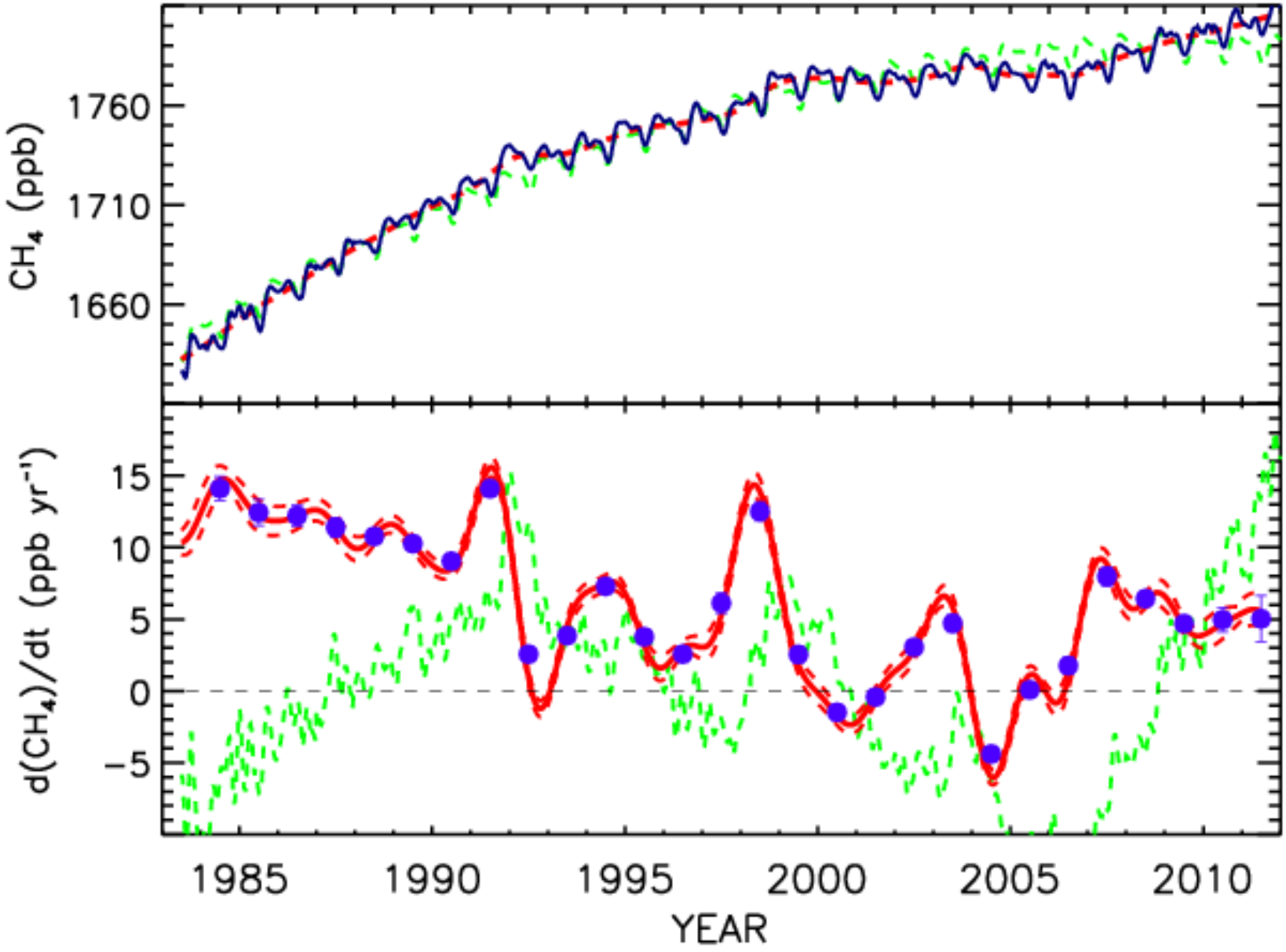
Steve Wofsy and Rachel Chang

Conclusions

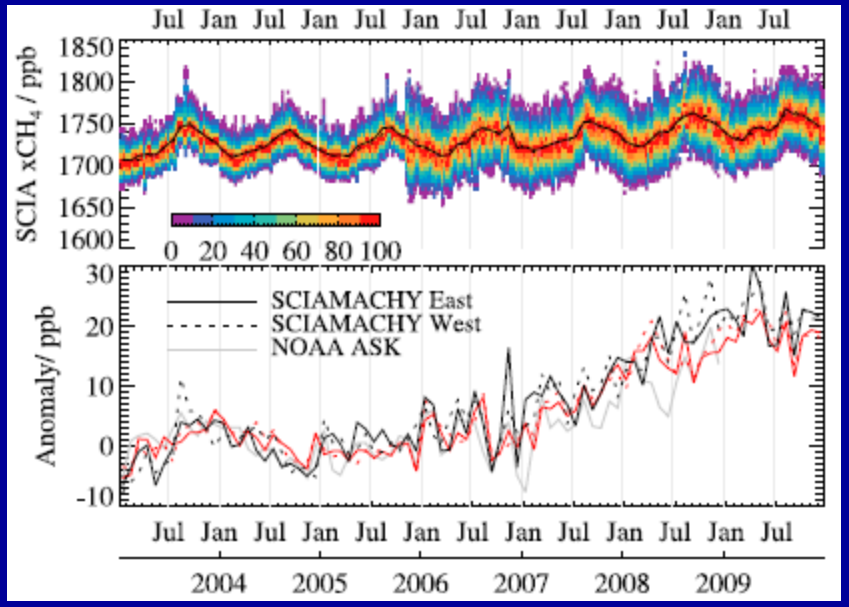
- Increased CH_4 GR in Arctic in 2007:
  - Emissions ~3-5 Tg CH_4 greater than average
  - $\delta^{13}C$ (CH_4) indicates wetland source
- No persistent increase in Arctic emissions:
  - IPD is strong constraint on Arctic emissions
  - No change in S-N CH_4 difference at BRW
- Process understanding from in situ observations:
  - Field campaigns (CARVE) → Processes
  - Satellite sensors: low S/N and disinformation

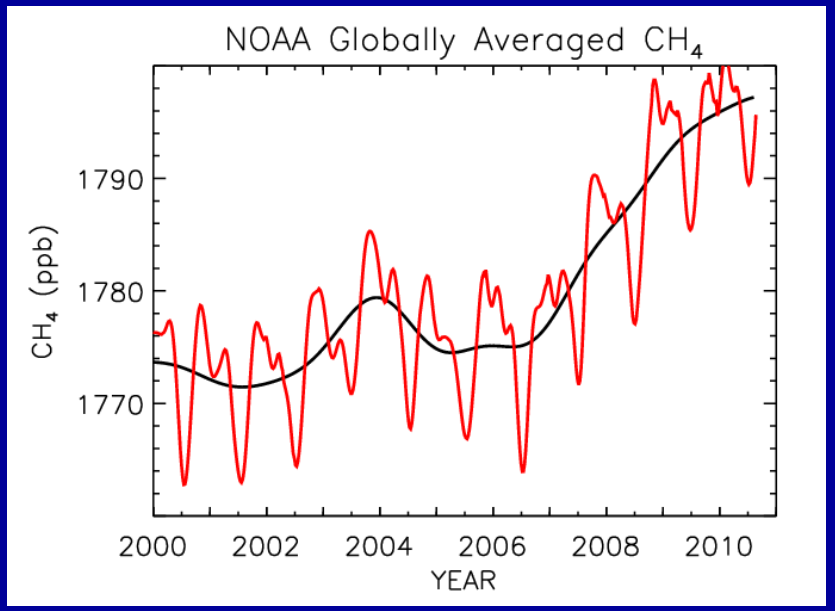
Arctic GHG Observation Network


Trop precip anom
Global CH4 residuals
ΔCH4 (nmol mol-1)
Precip Anom (mm d-1)
Running Mean
ENSO
SOI
Date
1980
1985
1990
1995
2000
2005
2010
2015


CH4 (ppb)
1760
1710
1660
d(CH4)/dt (ppb yr-1)
15
10
5
0
−5
1985
1990
1995
2000
2005
2010
YEAR

SCIAMACHY



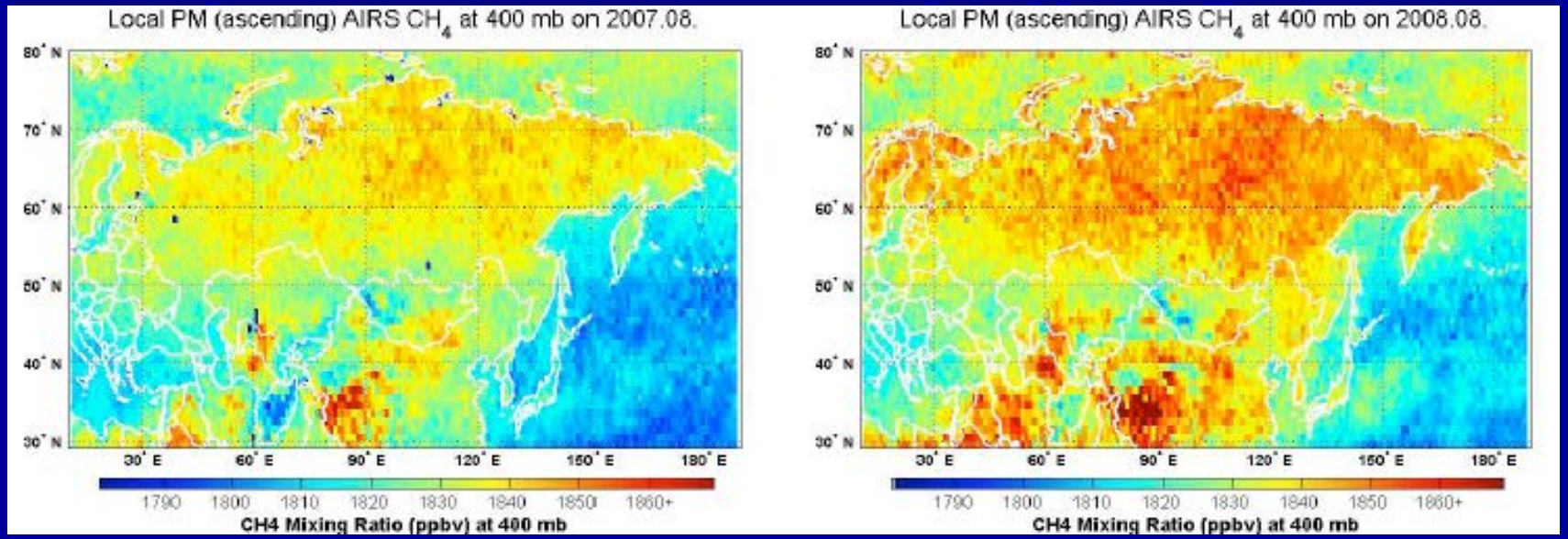


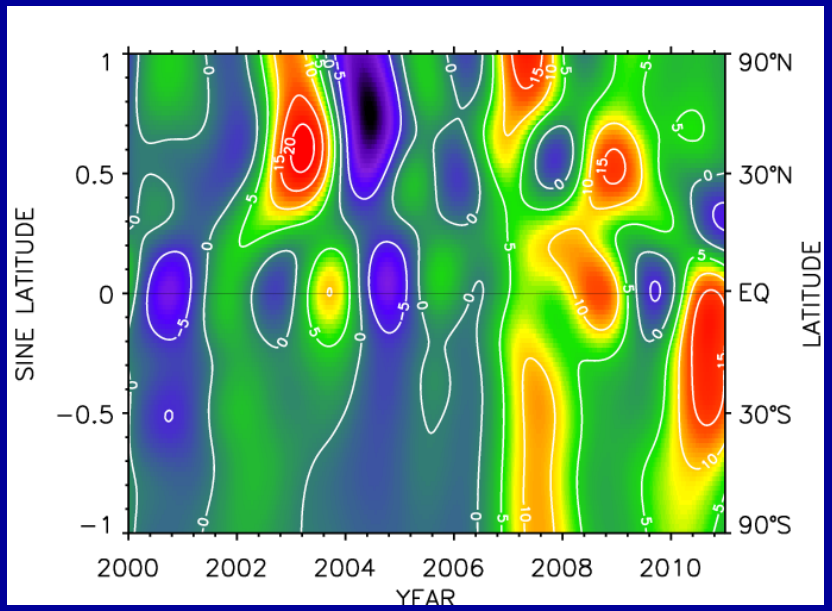
Increases in SCIA since 2007 consistent with in situ observations.

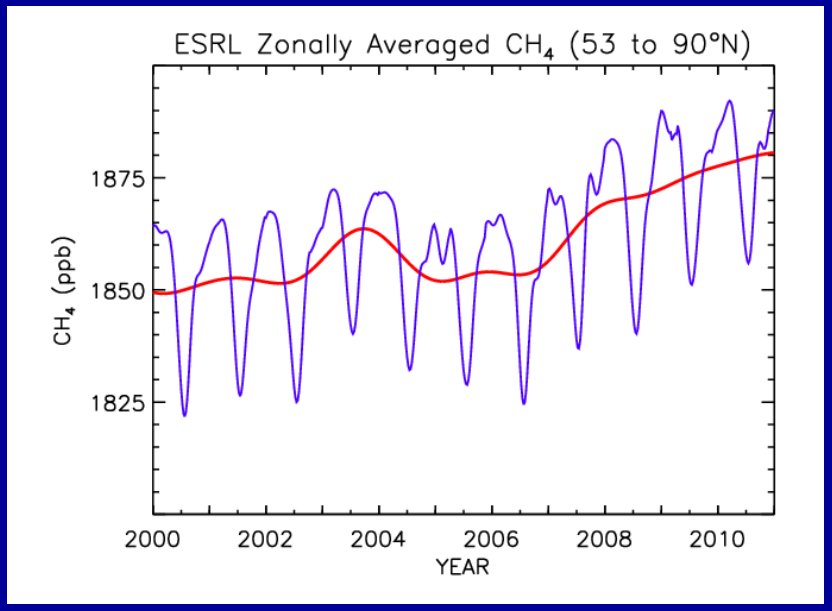
Insufficient S/N to identify cause of recent CH_4 increase.

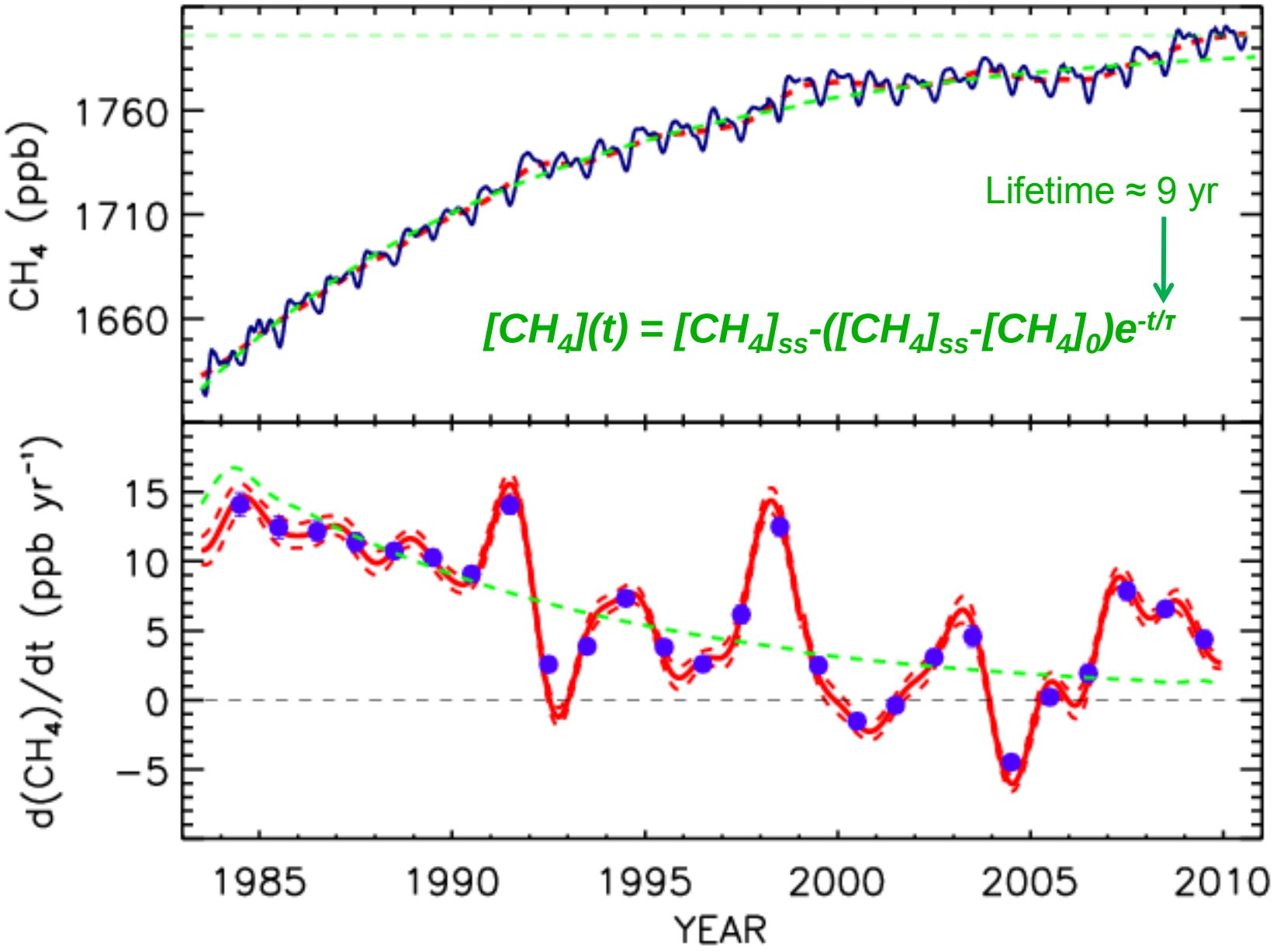
Frankenberg et al., JGR, 2011.

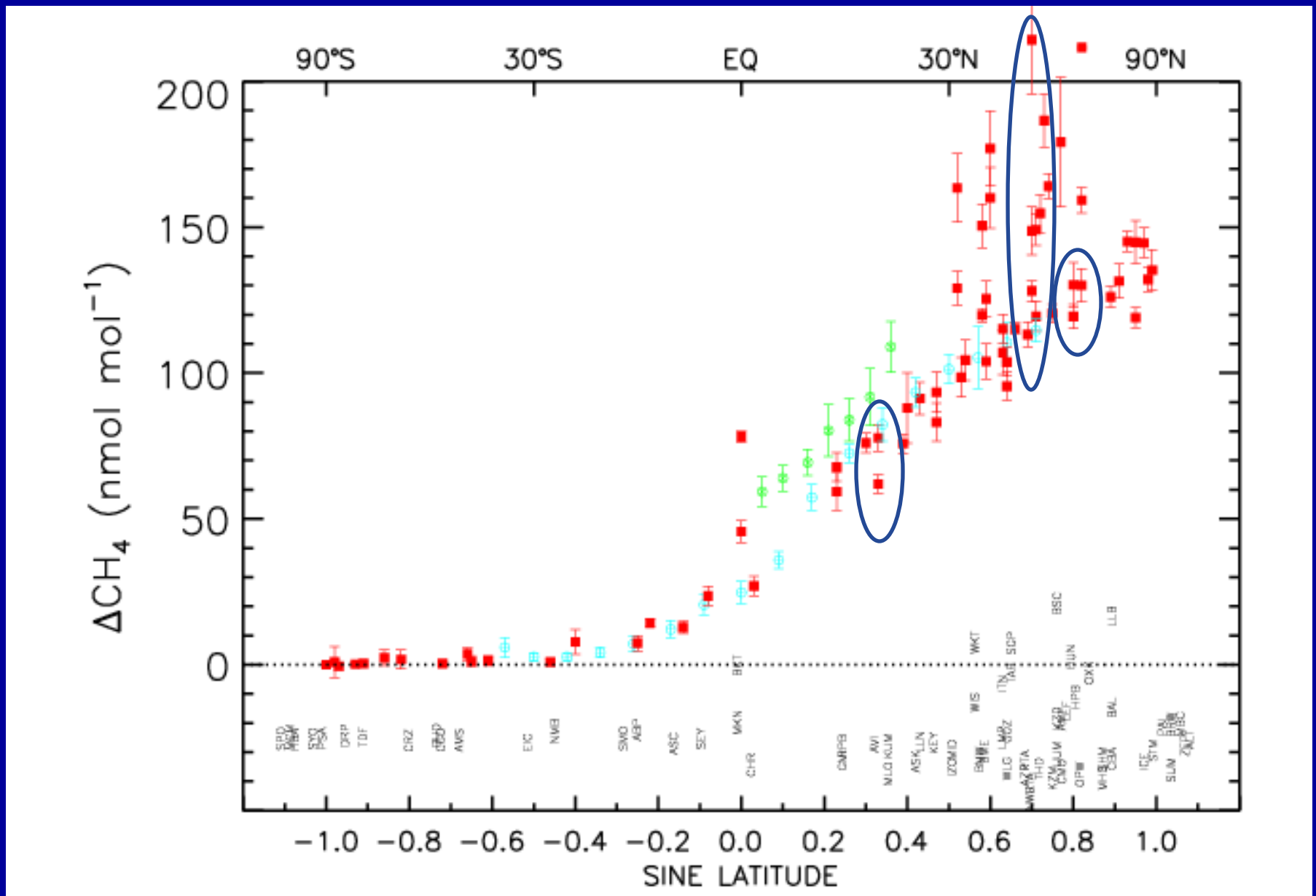
AIRS


Local PM (ascending) AIRS CH4 at 400 mb on 2007.08.
Local PM (ascending) AIRS CH4 at 400 mb on 2008.08.
80° N
70° N
60° N
50° N
40° N
30° N
30° E
60° E
90° E
120° E
150° E
180° E
1790
1800
1810
1820
1830
1840
1850
1860+
CH4 Mixing Ratio (ppbv) at 400 mb


SINE LATITUDE
1
0.5
0
−0.5
−1
90°N
30°N
EQ
30°S
90°S
LATITUDE
2000
2002
2004
2006
2008
2010
YEAR


ESRL Zonally Averaged CH4 (53 to 90°N)
CH4 (ppb)
1875
1850
1825
2000
2002
2004
2006
2008
2010
YEAR


CH4 (ppb)
1760
1710
1660
Lifetime ≈ 9 yr
[CH4](t) = [CH4]ss-([CH4]ss-[CH4]0)e-t/τ
d(CH4)/dt (ppb yr-1)
15
10
5
0
−5
1985
1990
1995
2000
2005
2010
YEAR


90°S
30°S
EQ
30°N
90°N
200
150
100
50
0
ΔCH4 (nmol mol−1)
−1.0
−0.8
−0.6
−0.4
−0.2
0.0
0.2
0.4
0.6
0.8
1.0
SINE LATITUDE

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.