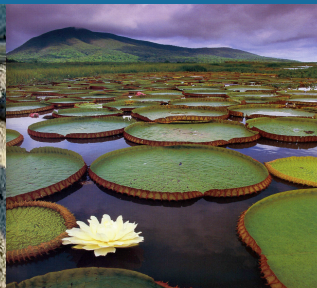


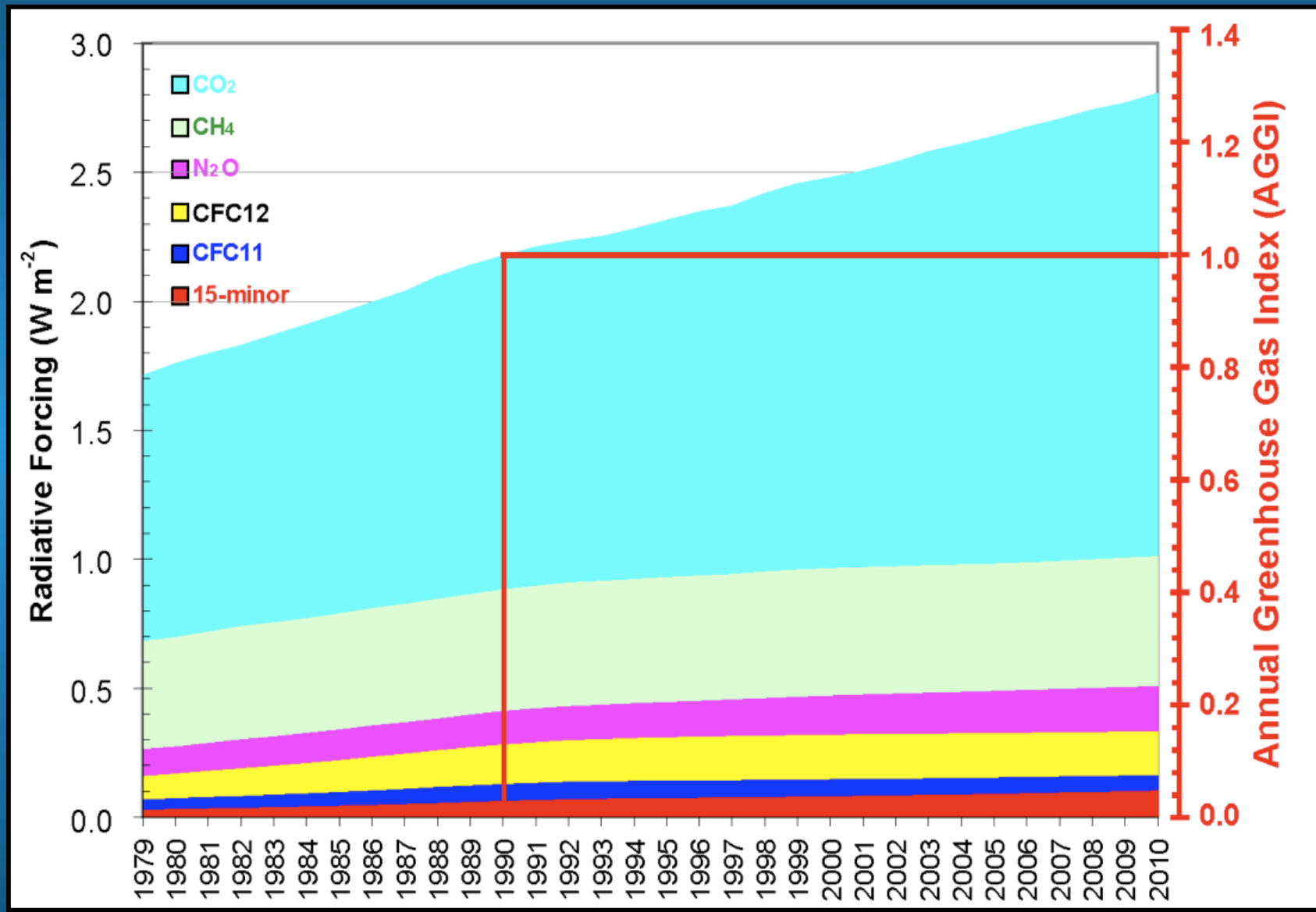


Understanding the Recent Evolution of Atmospheric Methane

Lori Bruhwiler, Ed Dlugokencky, Ken Masarie
NOAA Earth System Research Laboratory, Boulder, CO
(Pieter Tans & the NOAA ESRL CCGG Group)



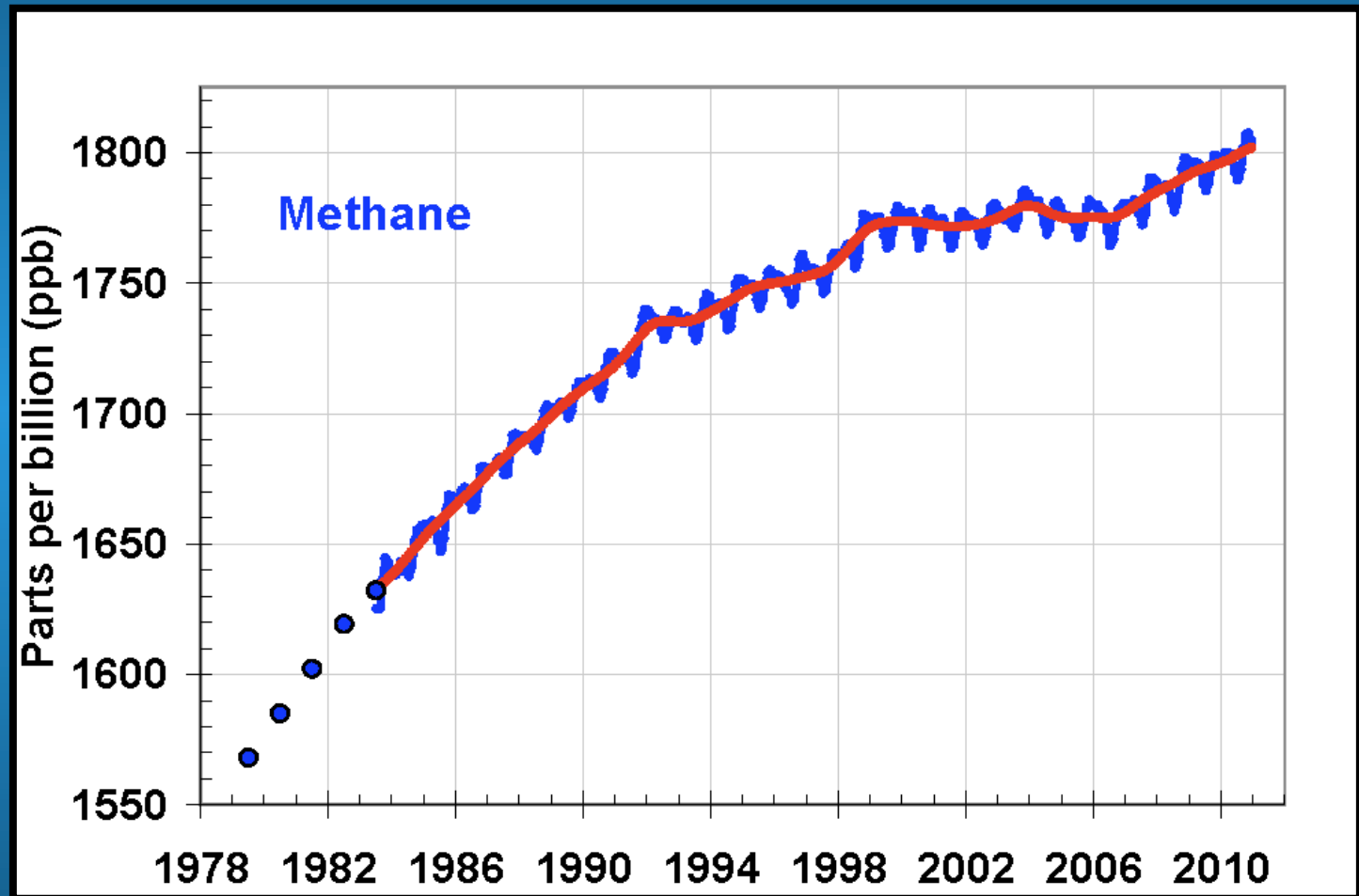
THE NOAA ANNUAL GREENHOUSE GAS INDEX (AGGI)



2001 Emissions: 526Tg/yr (Anthropogenic: EDGAR 3)

Coal	30	(TgCH ₄ /yr)
Oil/Gas	50	
Enteric Fermentation/Manure	100	
Rice	59	
Biomass Burning	32	
Waste	74	
Wetlands	174	
Wild Animals	5	
Termites	19	
Soil	-38	
Oceans	17	
Photochemical Loss (mostly reaction w/ OH)	$\tau \sim 10$ yrs	~ 500 Tg/yr

Is CH₄ Increasing Again? Why? Is it Temporary?



Source: NOAA ESRL Cooperative Air Sample Network

Permafrost Degradation?

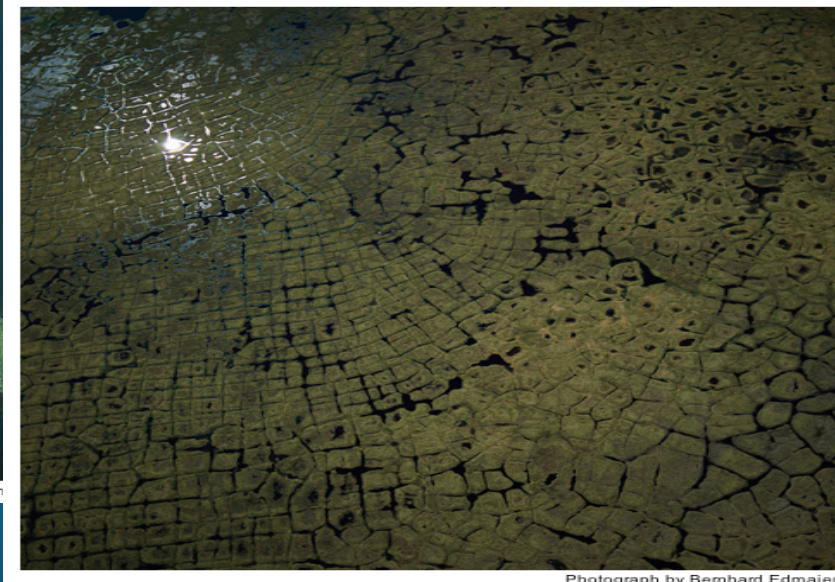
1400-1850 GtC Organic
Carbon Stored In Arctic
Permafrost
(McGuire et al, 2009)



Photograph by Ben



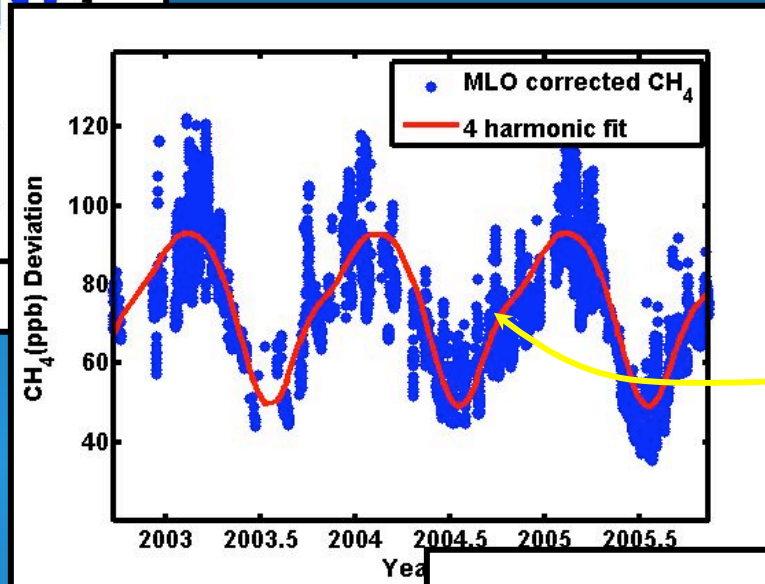
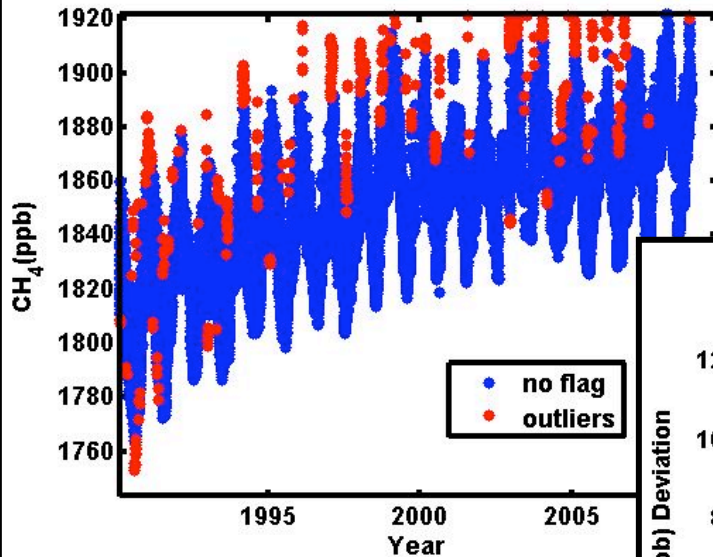
emhard Edmaier



Photograph by Bernhard Edmaier

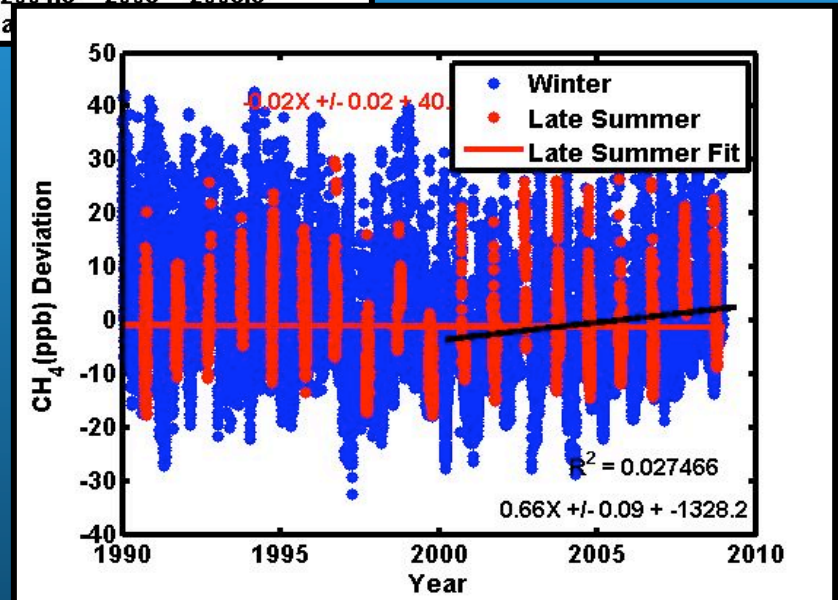
(Analysis by Colm Sweeney)

Barrow Trend



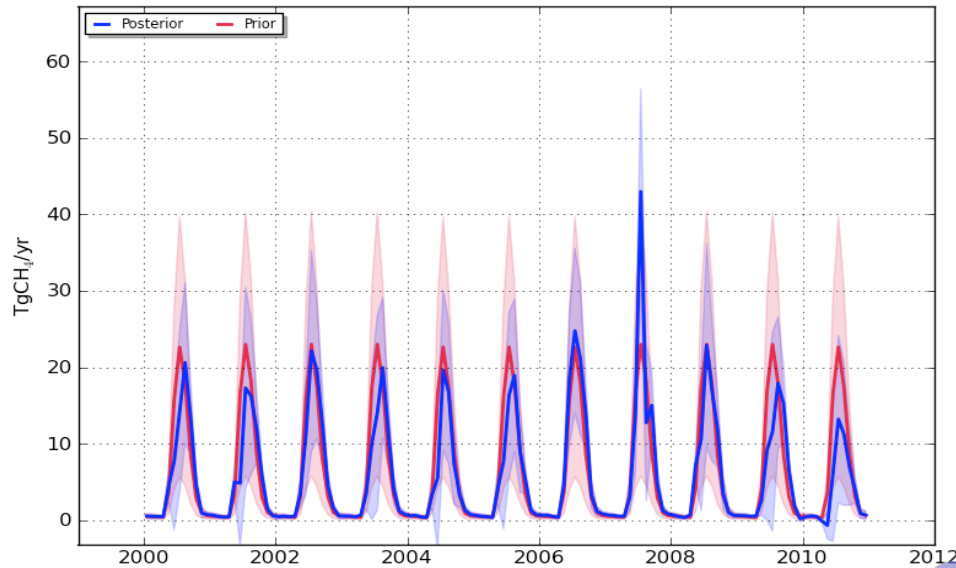
Deviation from MLO trend
Note shoulder of increase in CH₄ – August/Sept

No apparent trend in August/September shoulder that might be associated with melting
Note significant increase 2007



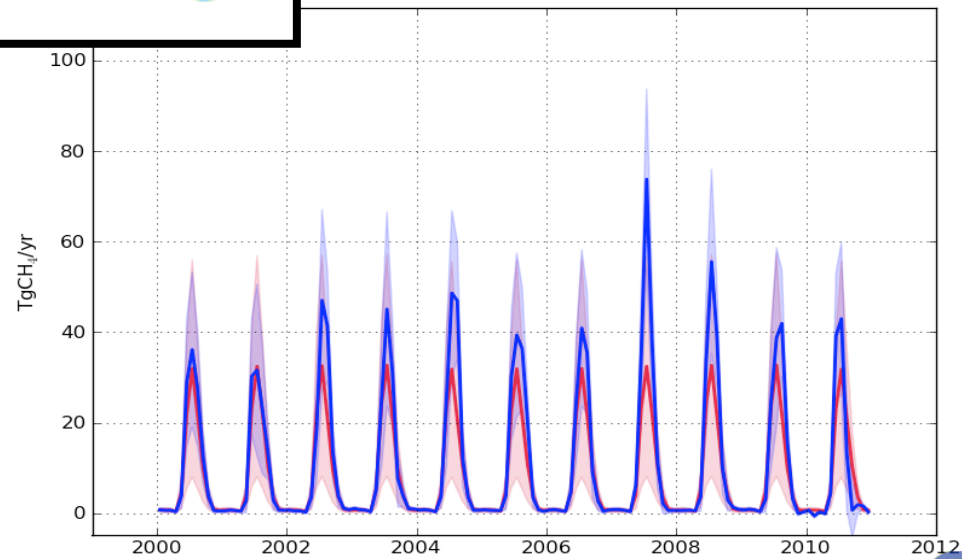
Regional Source Information from CarbonTracker-CH₄ Data Assimilation System

Natural
Boreal North America



CTCH4.v1, Created 25 October 2011

Natural
Boreal Eurasia



CTCH4.v1, Created 25 October 2011

GISS Surface Temperature Analysis

Sources and parameters: GHCN_GISS_HR2SST_1200km_Anom0603_2007_2007_1951_1980

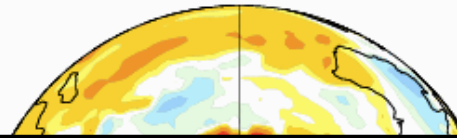
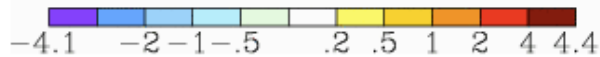
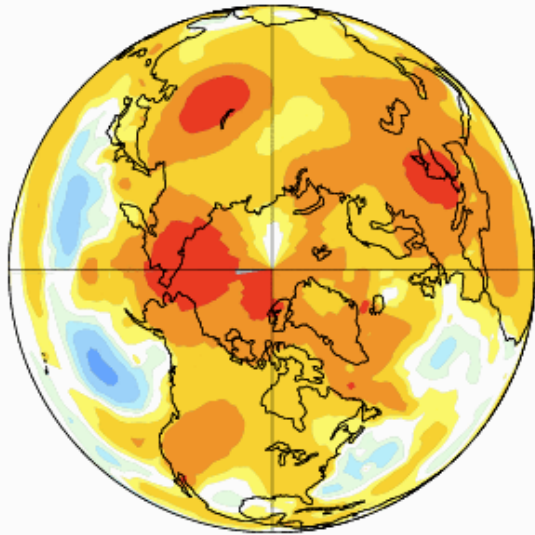
Note: Gray areas signify missing data.

Graphics bug: Occasionally the color for the .5-1C range is replaced by gray.

Note: Ocean data are not used over land nor within 100km of a reporting land station.

Jun-Jul-Aug 2007

L-OTI(°C) Anomaly vs 1951-1980 .52



GISS Surface Temperature Analysis

Sources and parameters: GHCN_GISS_HR2SST_1200km_Anom0603_2008_2008_1951_1980

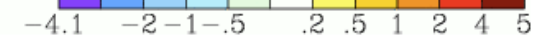
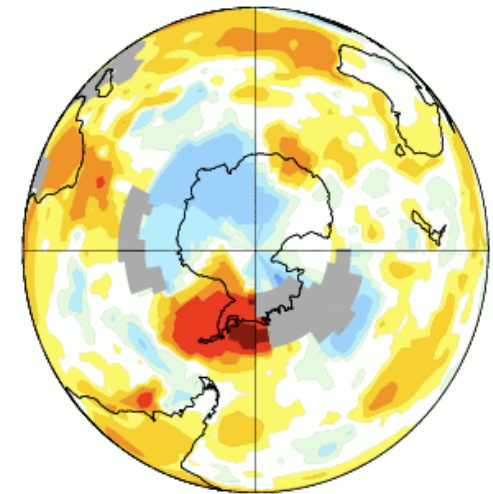
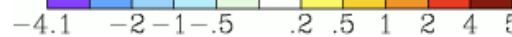
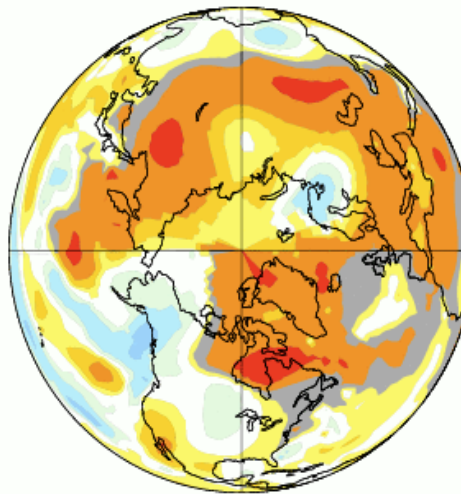
Note: Gray areas signify missing data.

Graphics bug: Occasionally the color for the .5-1C range is replaced by gray.

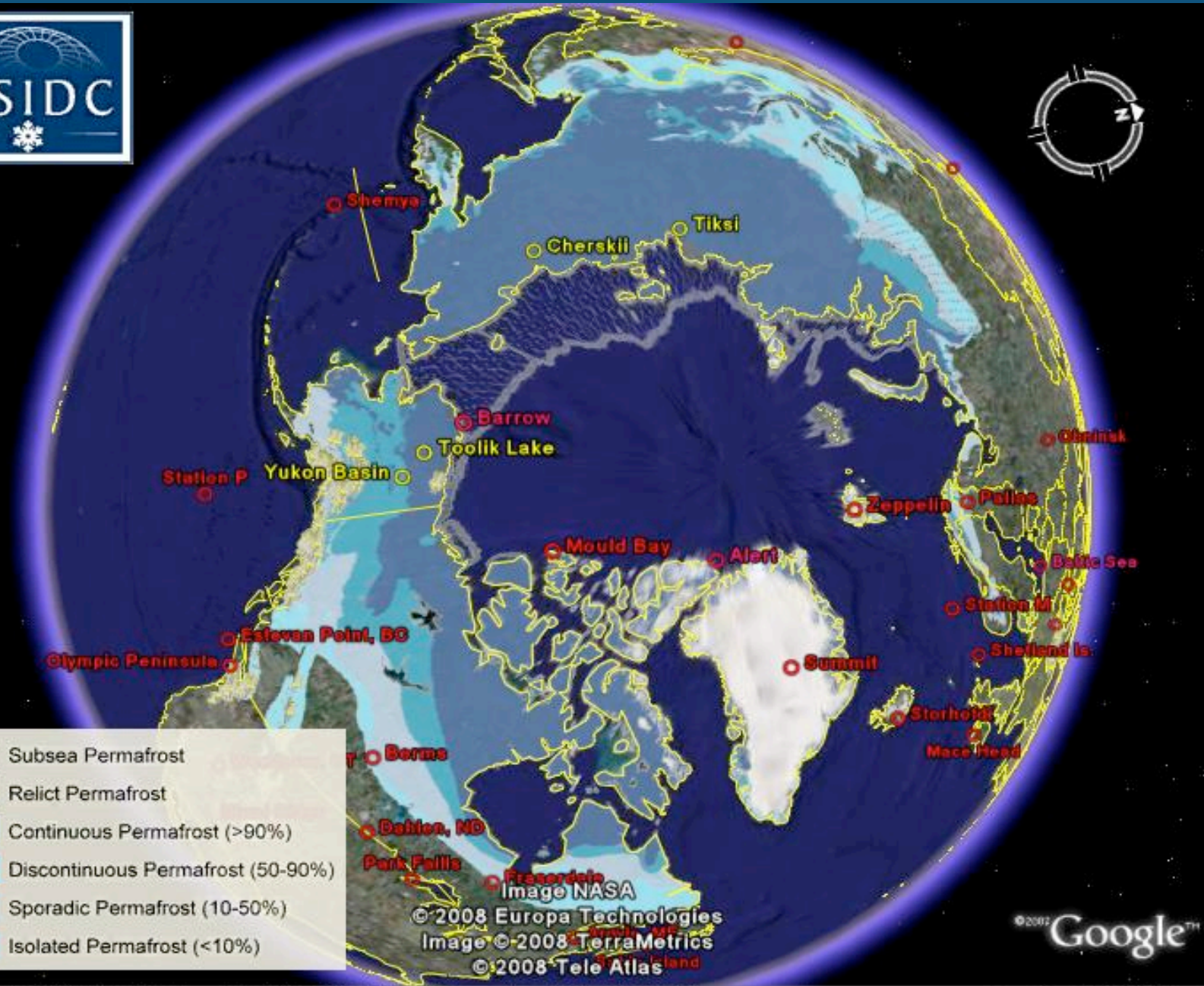
Note: Ocean data are not used over land nor within 100km of a reporting land station.

Jun-Jul-Aug 2008

L-OTI(°C) Anomaly vs 1951-1980 .40



2008 was also
warm in Boreal
Eurasia



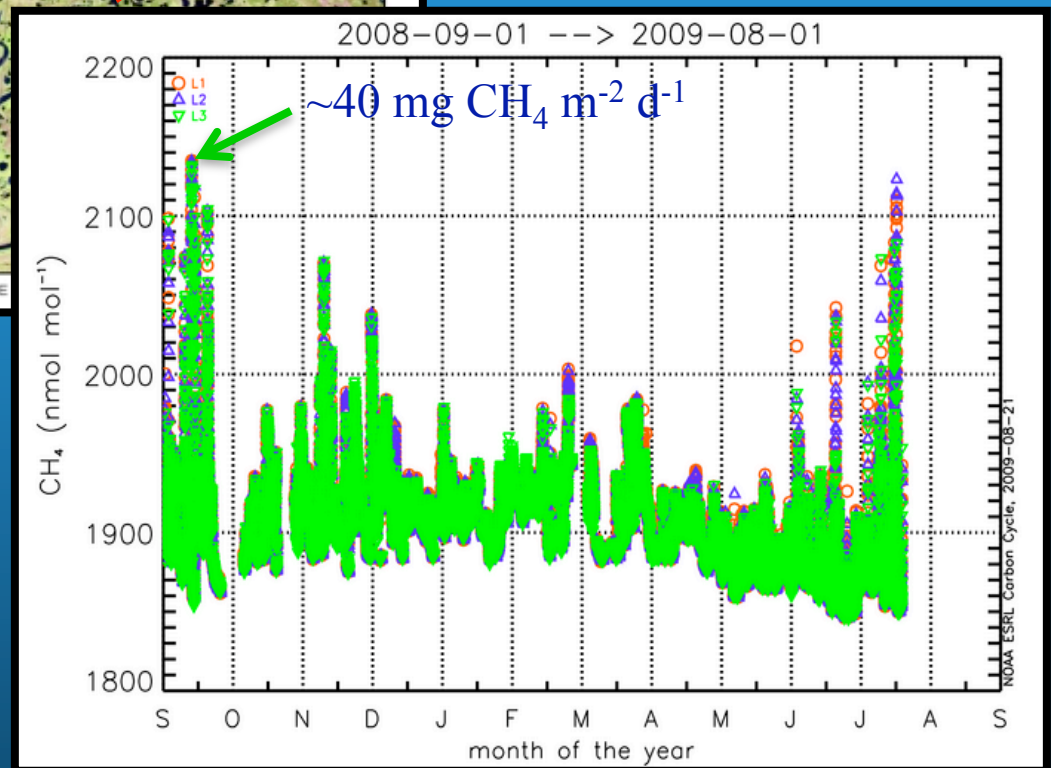
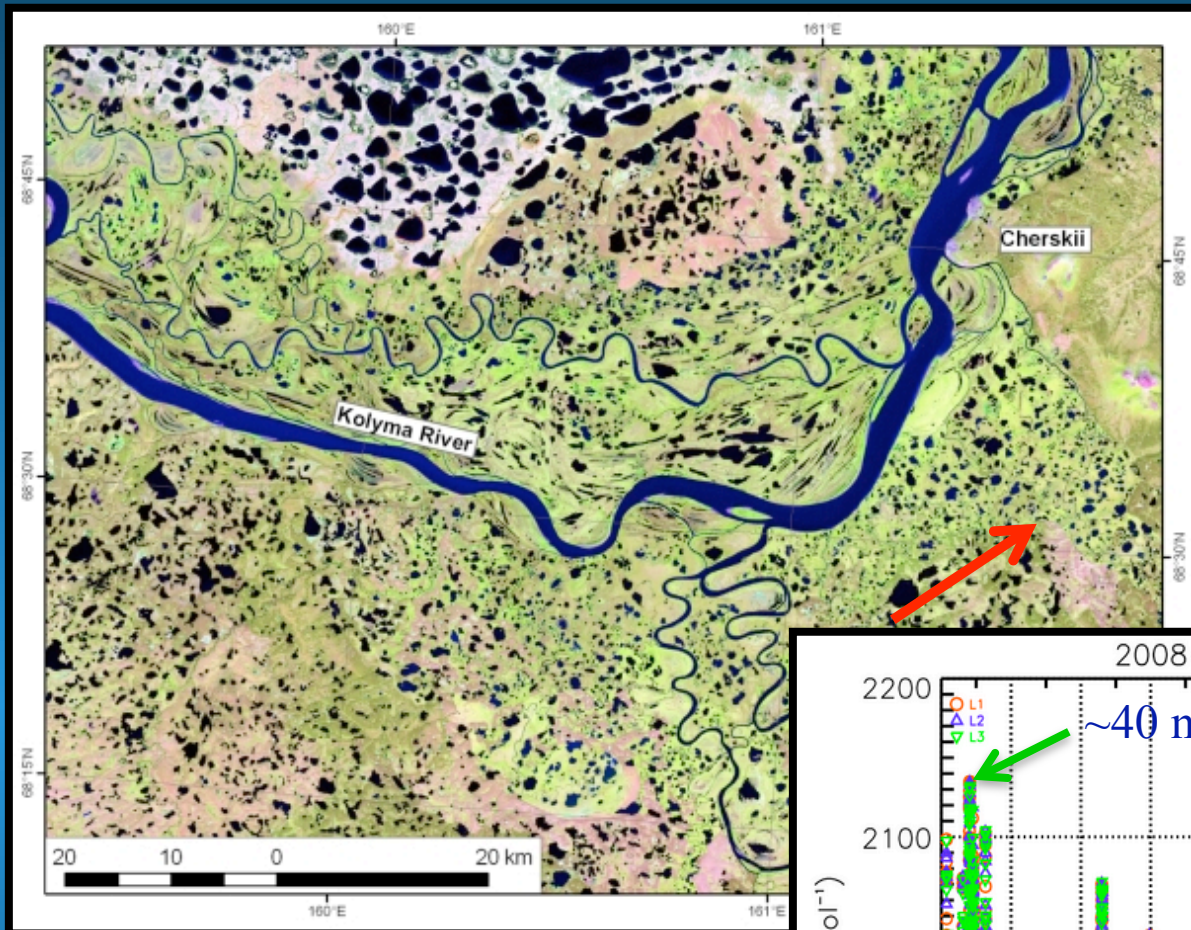
- Subsea Permafrost
- Relict Permafrost
- Continuous Permafrost (>90%)
- Discontinuous Permafrost (50-90%)
- Sporadic Permafrost (10-50%)
- Isolated Permafrost (<10%)

Image NASA
© 2008 Europa Technologies
Image © 2008 TerraMetrics
© 2008 Tele Atlas

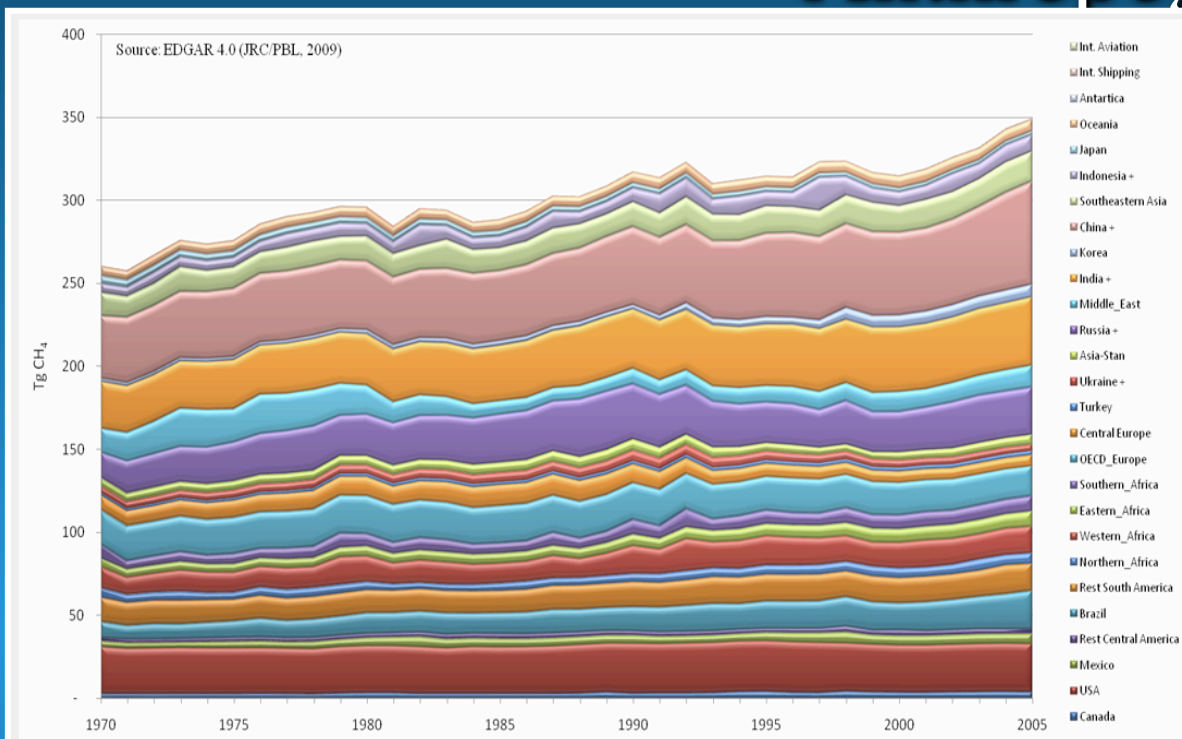
© 2008 Google™

Pointer 78°26'24.62" N 134°25'47.27" W Streaming ||||| 100%

Eye alt 8673.80 km



Anthropogenic Sources

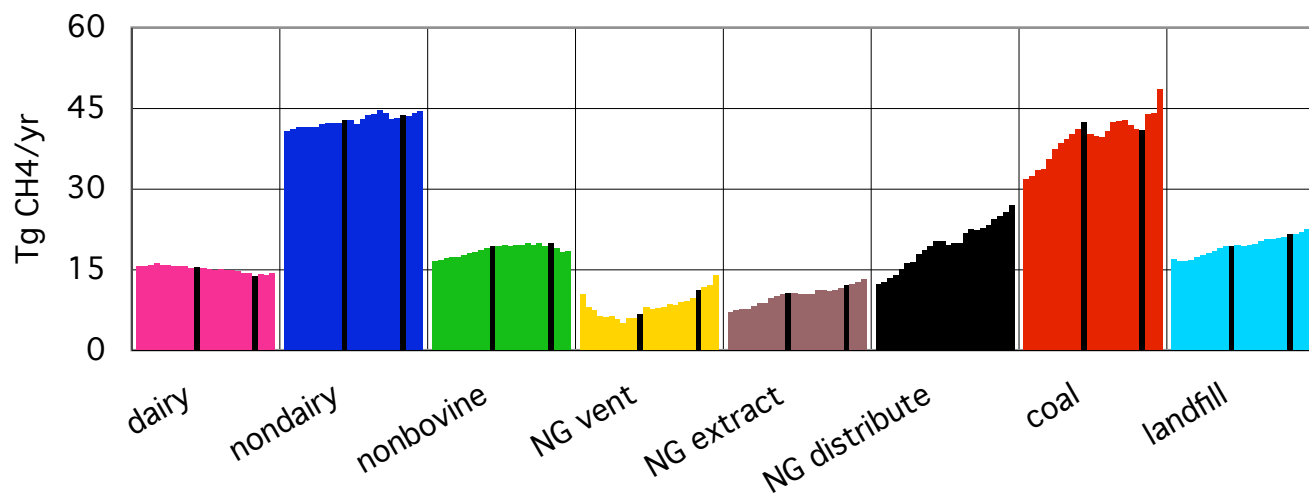


Can we see these
Increases in CT-CH₄?

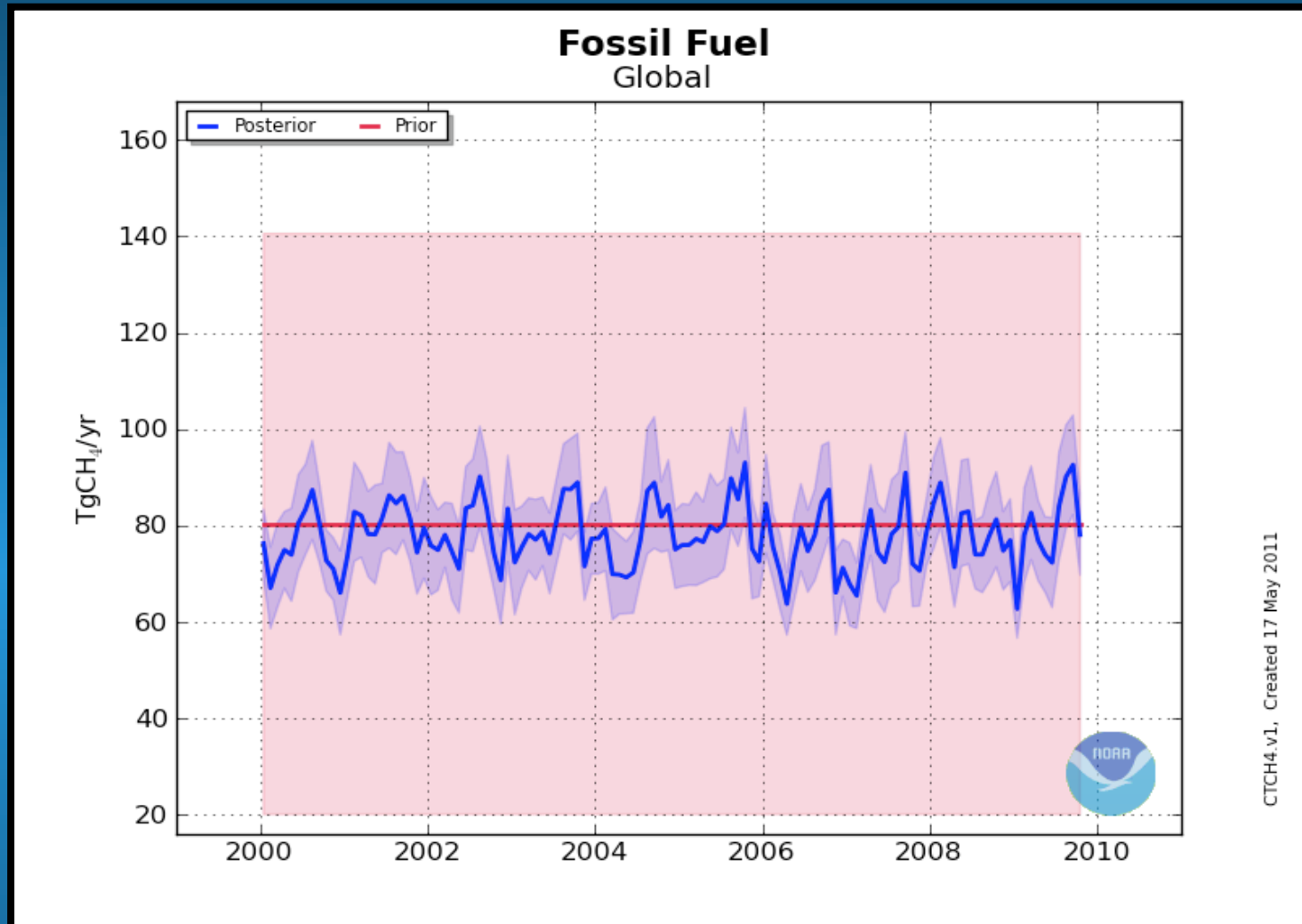
← 10Tg/yr since 2000

Figure 1: Global methane emissions by world region (1970-2005) in Tg C

Source: EDGAR 4.0,
J. Van Aardenne



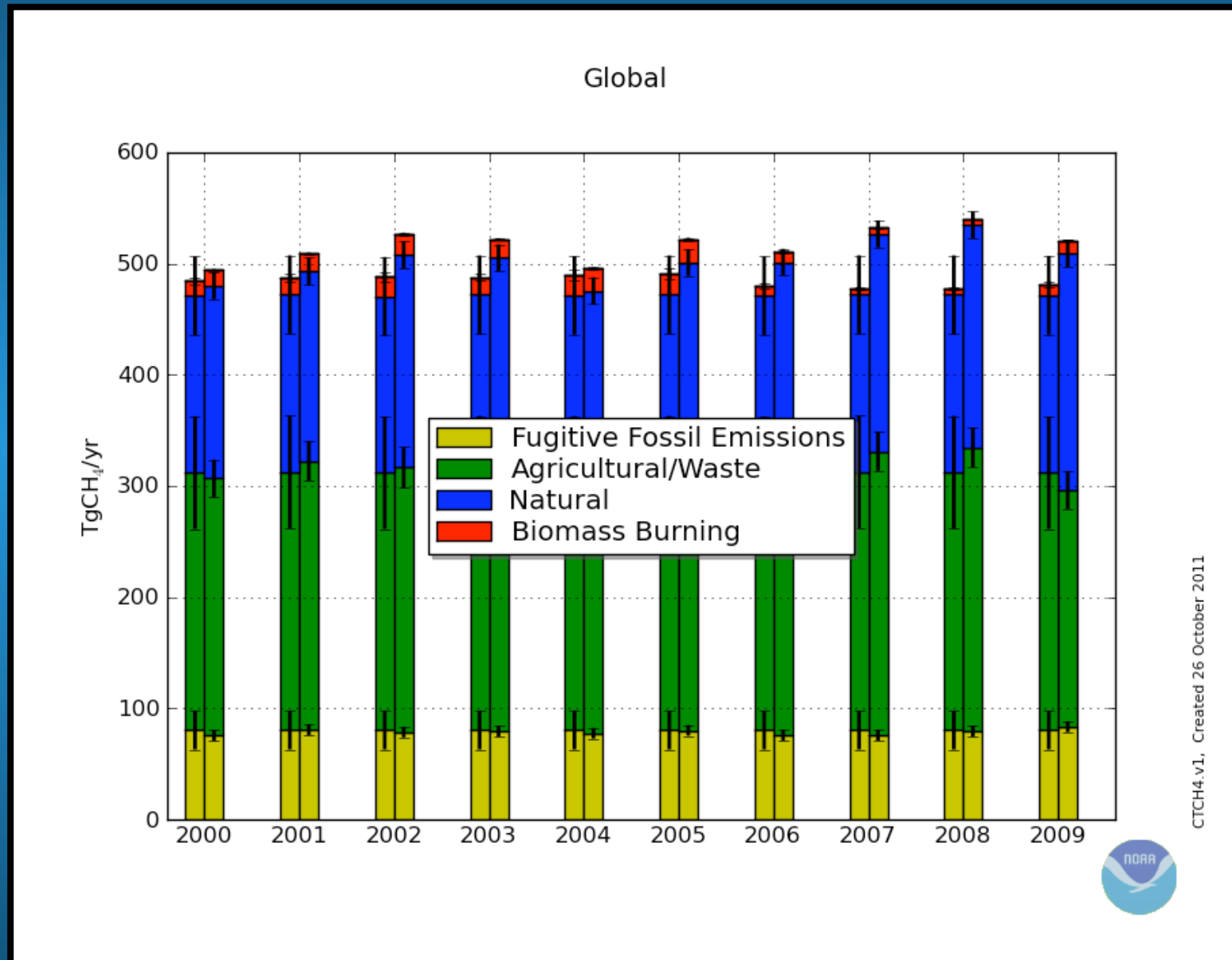
Source: E. Matthews



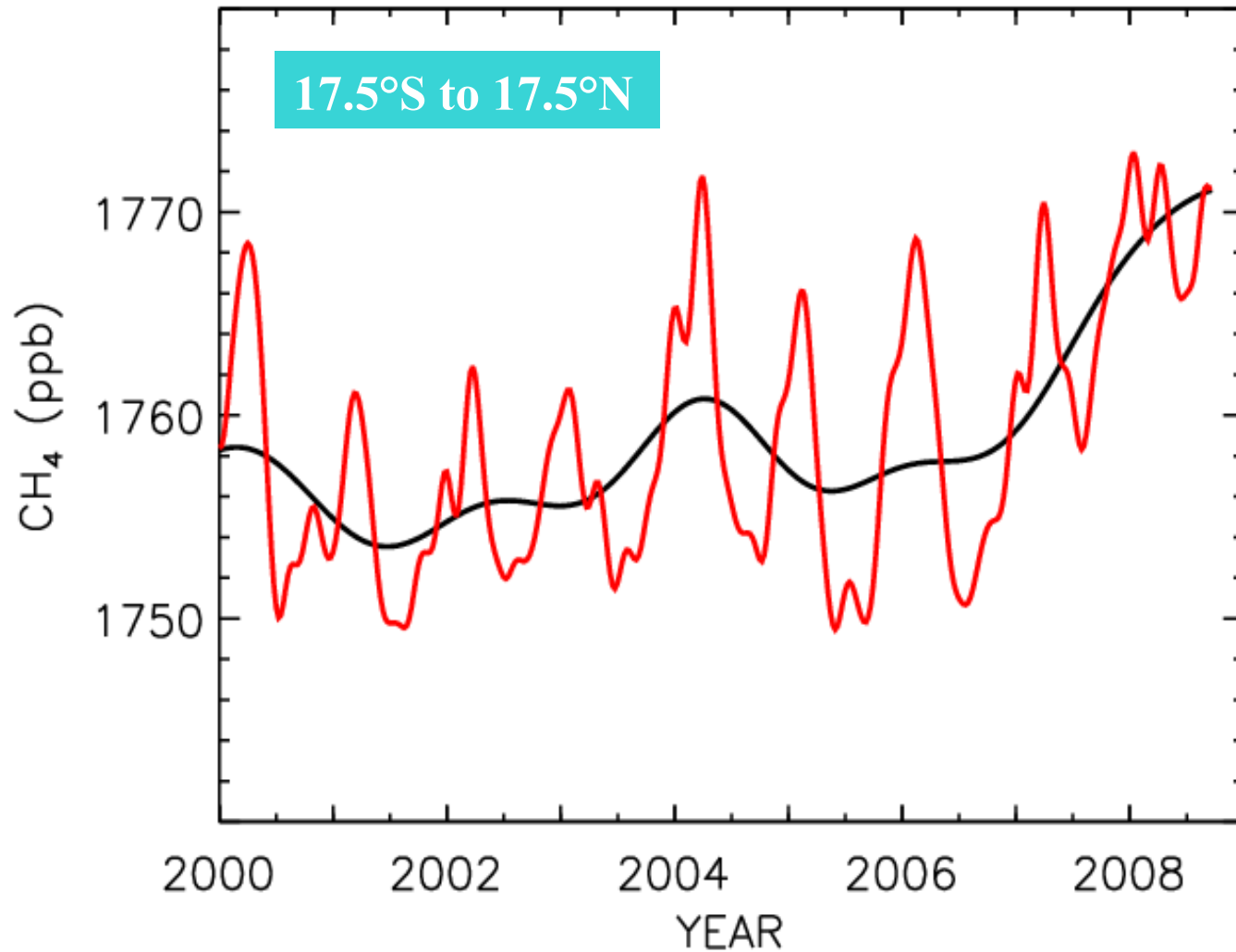
No trend!

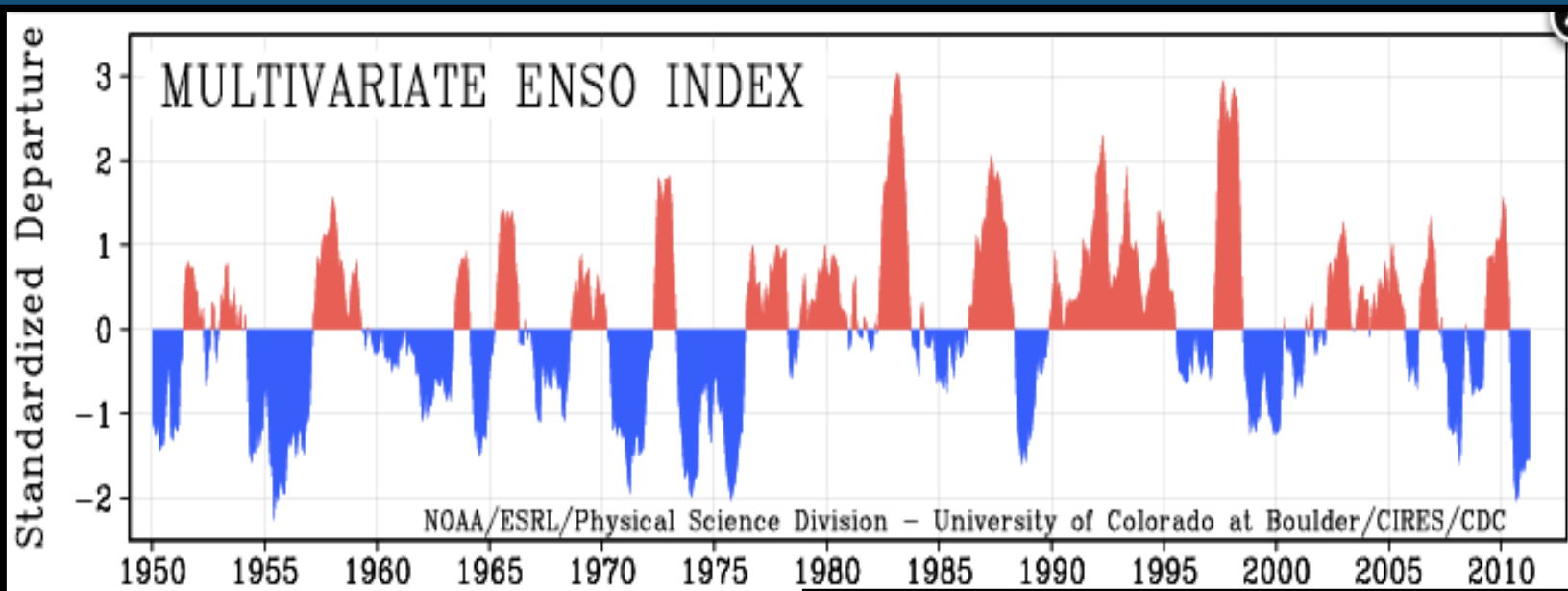
Time series is noisy and remains close to prior
(similar figure for Asia)

Hard to see a ~ 40 TgCH₄/yr increase over 2000-2005

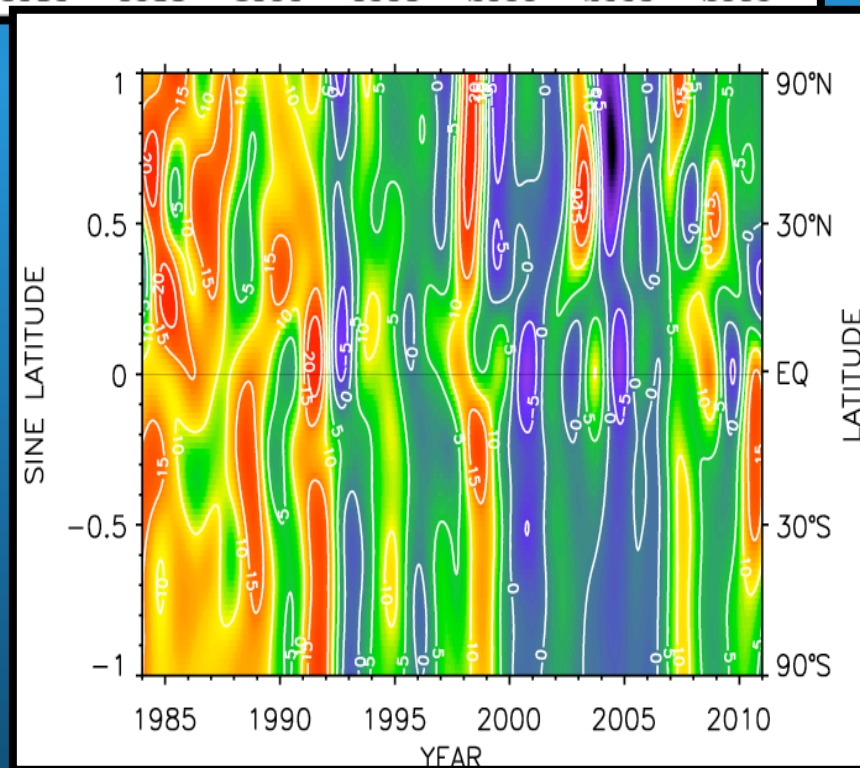


Observed CH₄ in the Tropics has Been Increasing Since ~2006 !

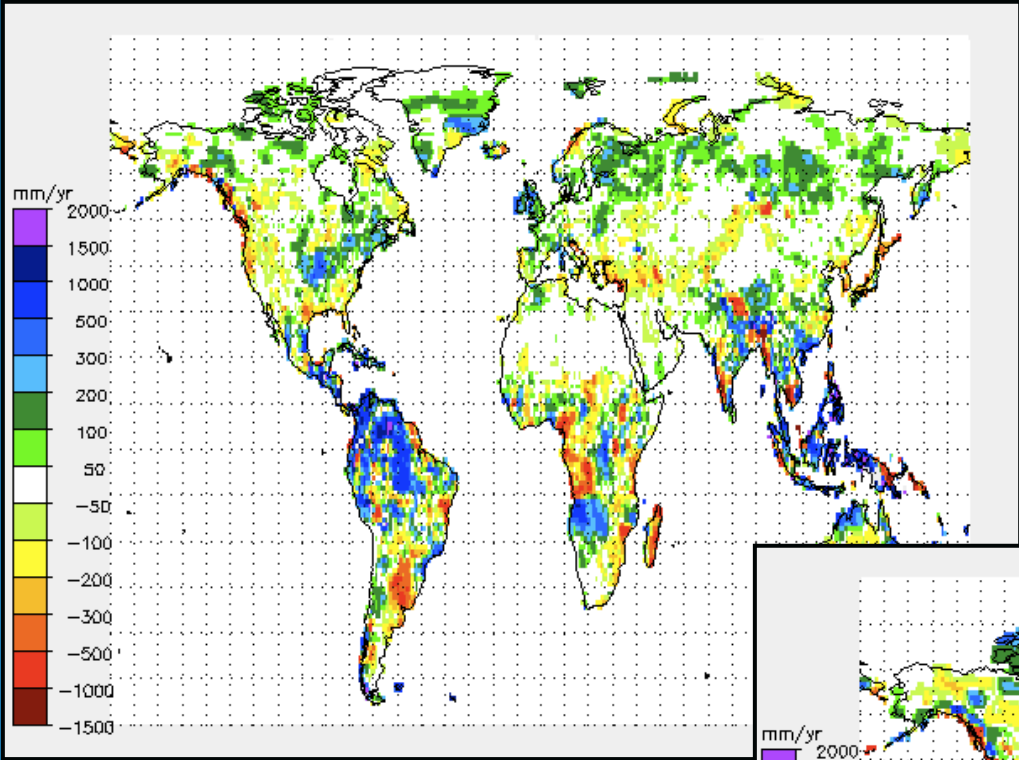




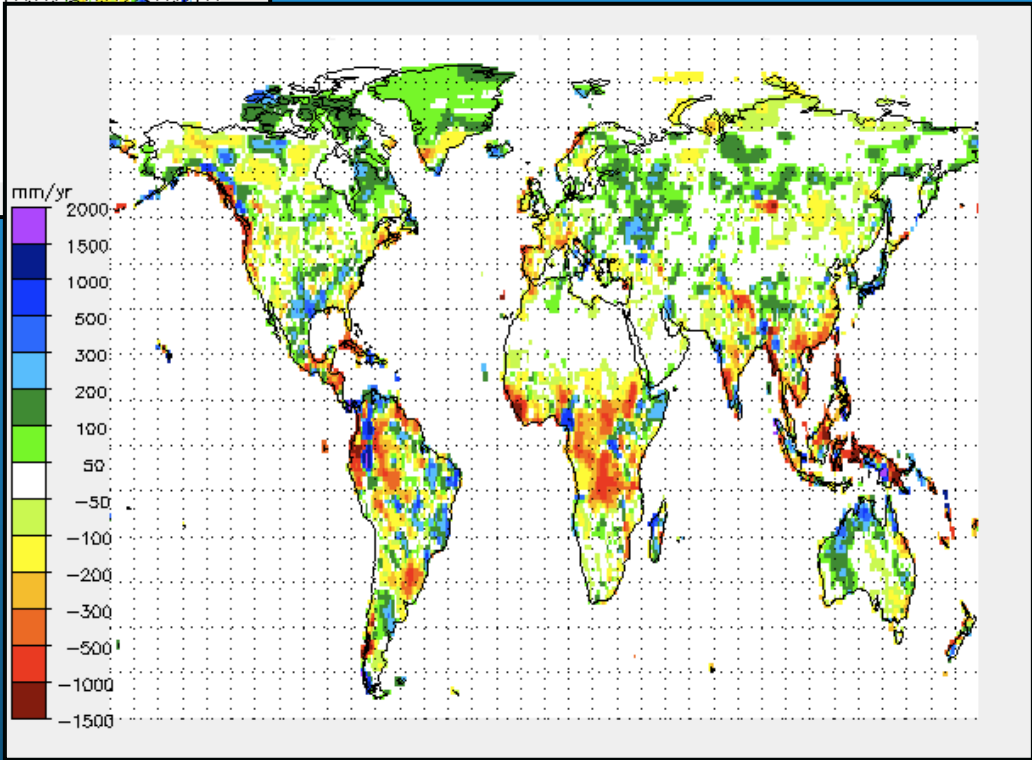
Correlation Between
ENSO and Tropical
CH₄ Sources?



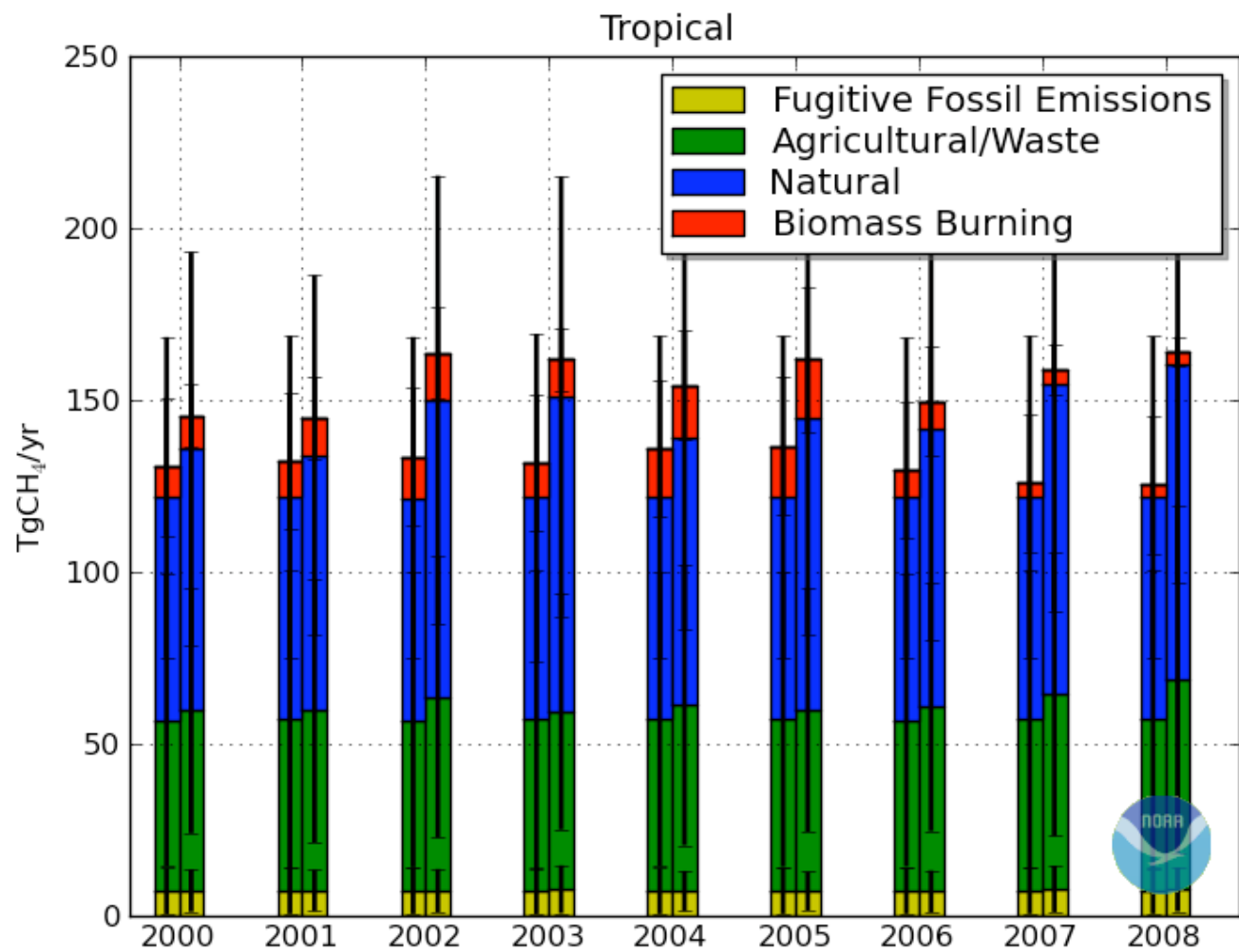
Composite Precipitation - La Niña

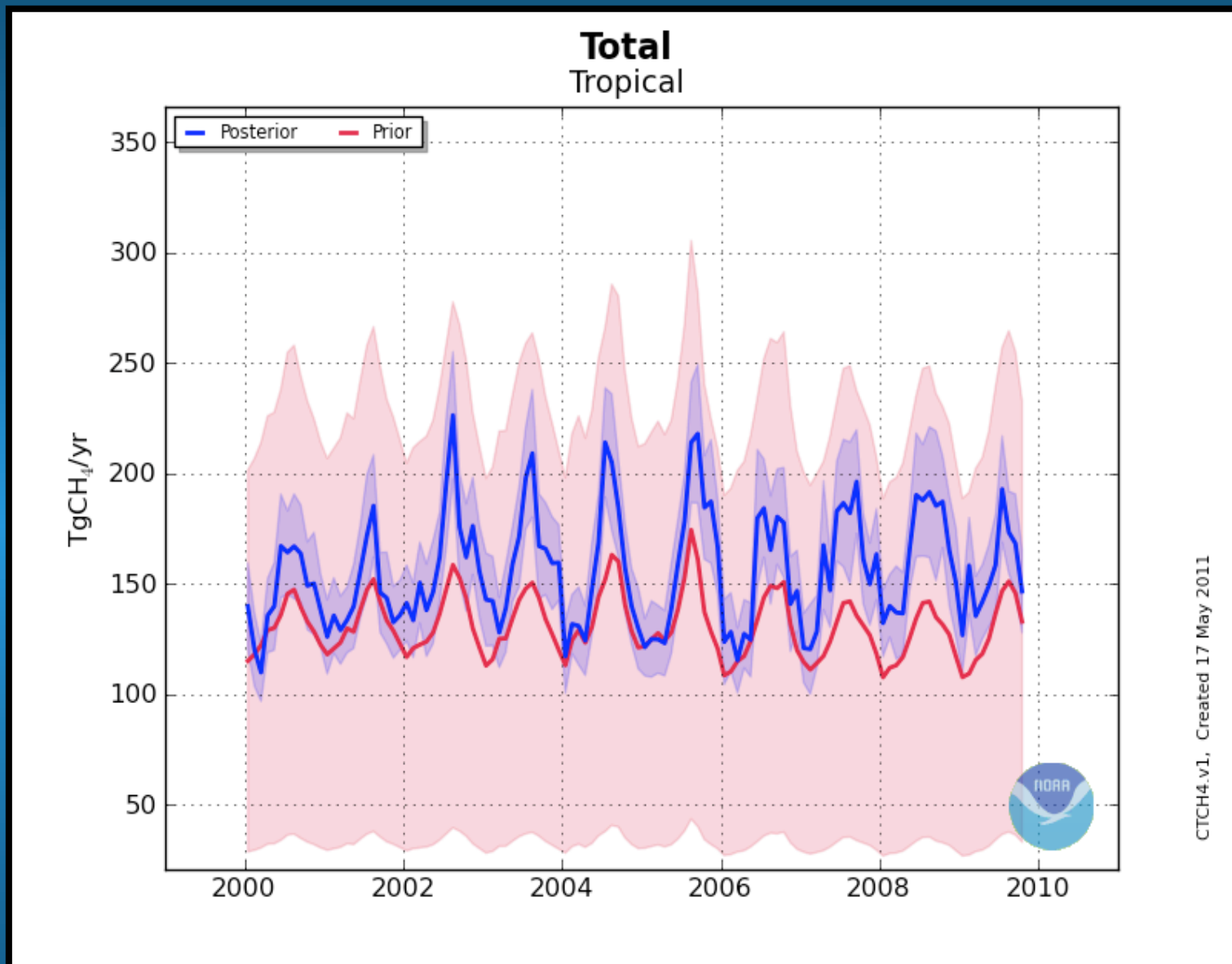


El Niño



Source: GPCP



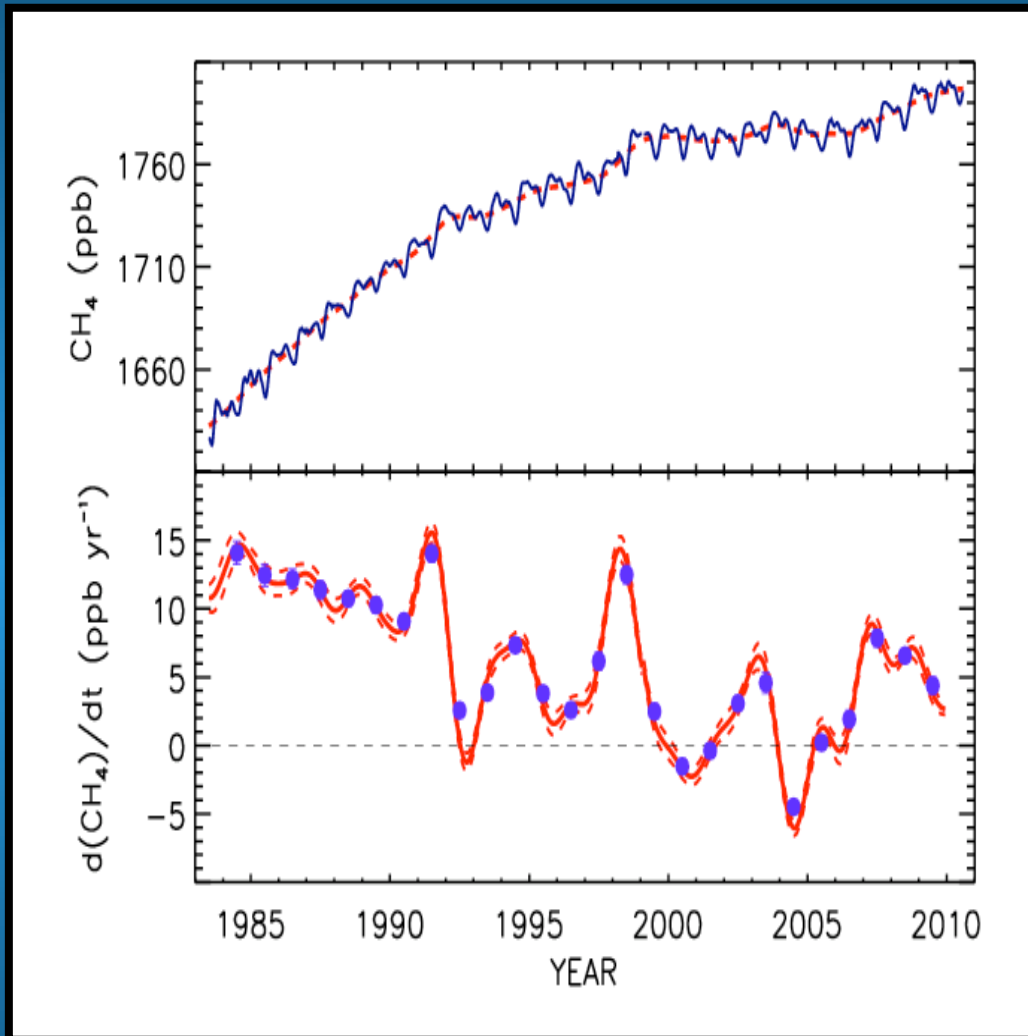


Could the seasonal cycle be changing?

Conclusions

- Atmospheric CH₄ may be on the rise again (since ~2006)!
- There is no evidence in the surface network observations of rapid mobilization of Arctic carbon stores (yet...). Inter-annual variability in response to temperature is observed.
- Increases in anthropogenic emissions of CH₄ over 2000-2005 appear to be inconsistent with global surface observations.
- Tropical emissions have been higher than normal recently. This is likely linked to variability in precipitation.
- Coming soon: CarbonTracker-CH₄ web site.

Observed Global Growth Rate



8.3 ± 0.2 ppb in 2007;

4.4 ± 0.2 ppb in 2008

(Dlugokencky et al. 2009)

Dlugokencky et al. (GRL, 2003) proposed that methane is approaching steady state - but some sources are thought to be increasing.

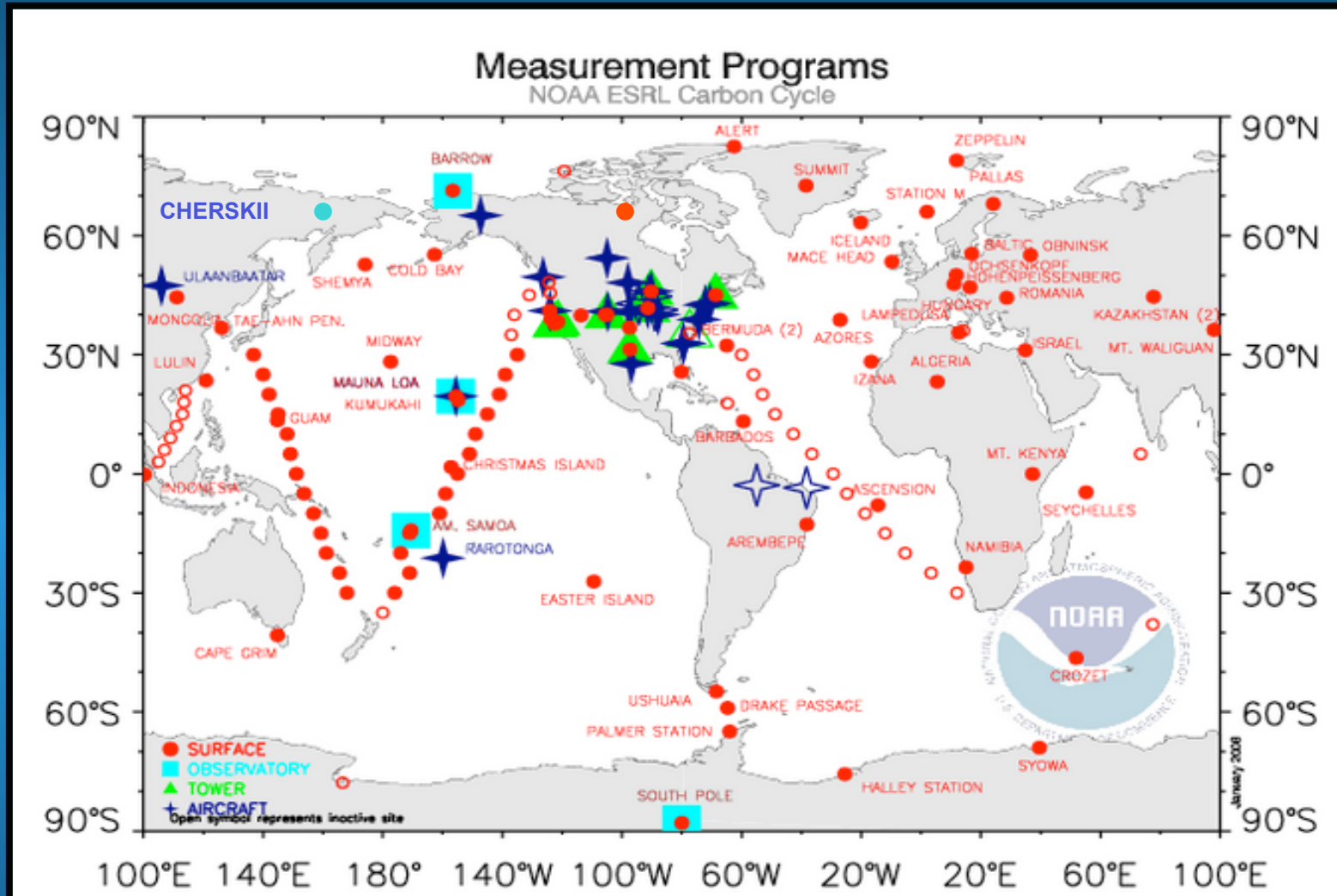
Why is growth slowing?

What causes variability?

What is happening since ~2006? Is it temporary?

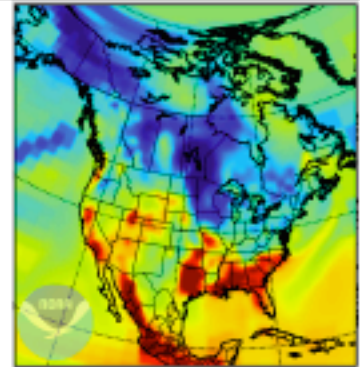
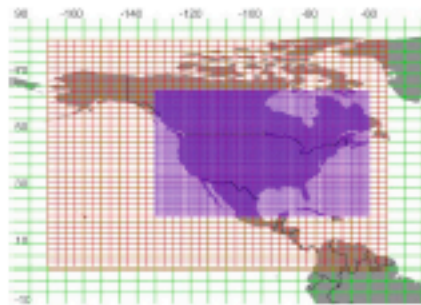
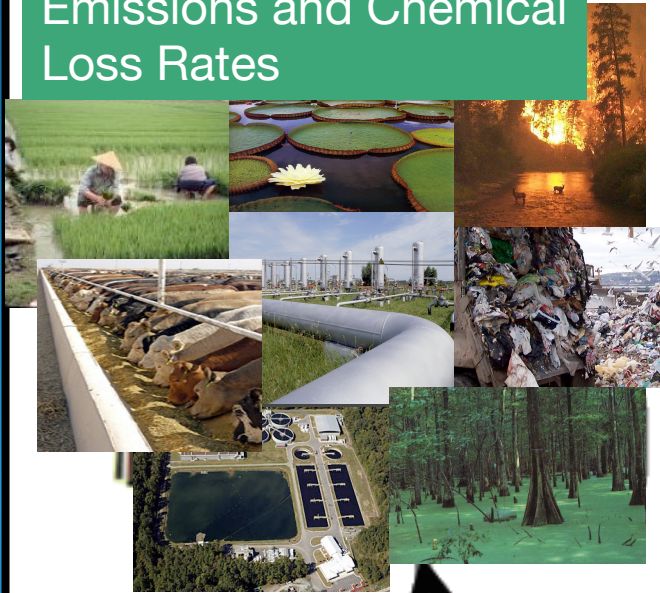
Can “Top-Down Approaches Help us to understand what drives variability and trends?

The Cooperative Air Sampling Network



(www.esrl.noaa.gov/gmd/ccgg/iadv/)

Best Estimates of Emissions and Chemical Loss Rates



TM5
2-way nested
transport

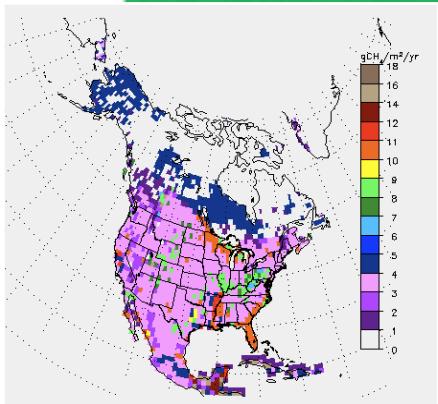
Simulated
CH₄

Observed
CH₄



Flux adjustments

Ensemble
Kalman Filter



$$J(\mathbf{x}) = \frac{(y - H(\mathbf{x}))^2}{R} + \frac{(\mathbf{x} - \mathbf{x}^P)^2}{P}$$