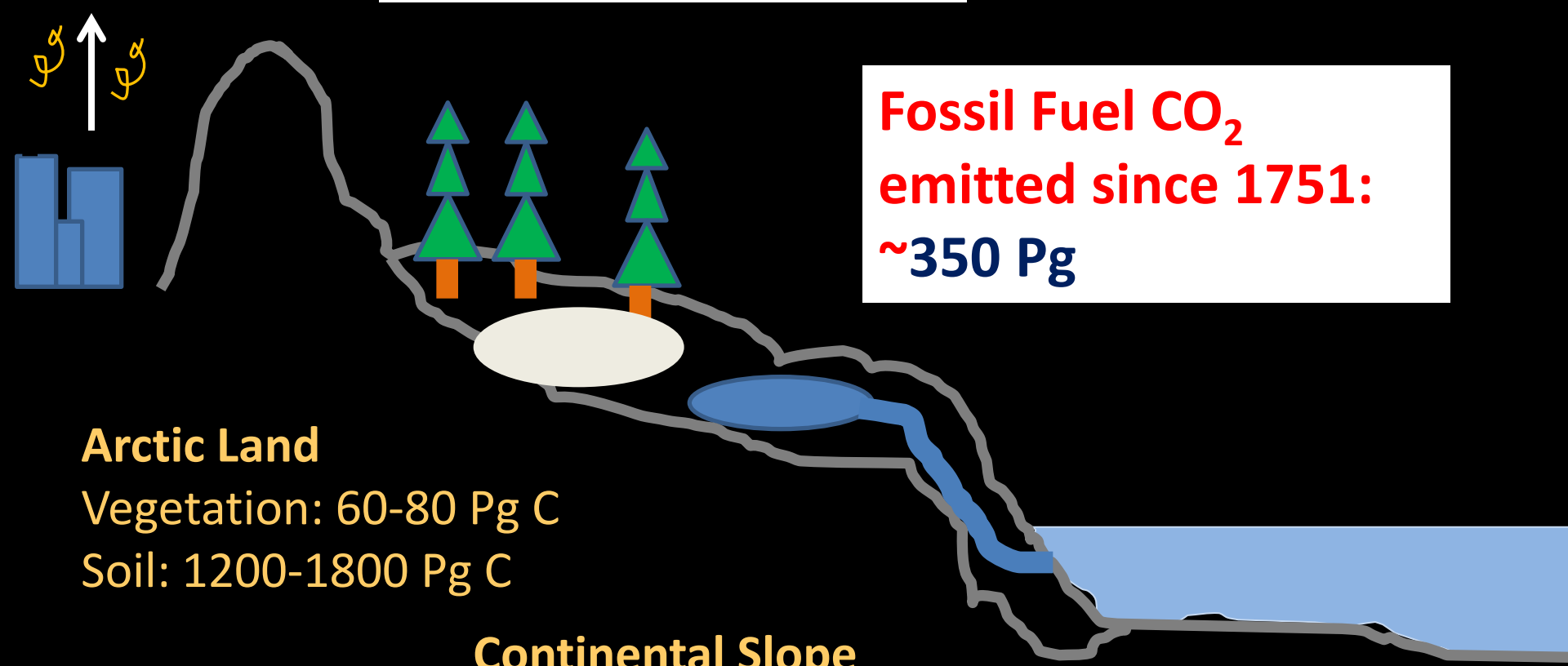
The Arctic Methane Paradox

Colm Sweeney

Lori Bruhwiler, Charles Miller, Ed Dlugokencky, John Miller, Anna Karion, Sonja Wolter, Doug Worthy, James White

>2000 PgC could be released as CH_4 or CO_2



Fossil Fuel CO_2 emitted since 1751: ~350 Pg

Arctic Land
Vegetation: 60-80 Pg C
Soil: 1200-1800 Pg C

Continental Slope permafrost/hydrate
2-65 Pg CH_4

Arctic Ocean floor
30-170 Pg CH_4

Anthropogenic

Energy: 10 - 17 Tg CH_4/yr

Biomass burning: 0.5 - 2.5 Tg CH_4/yr

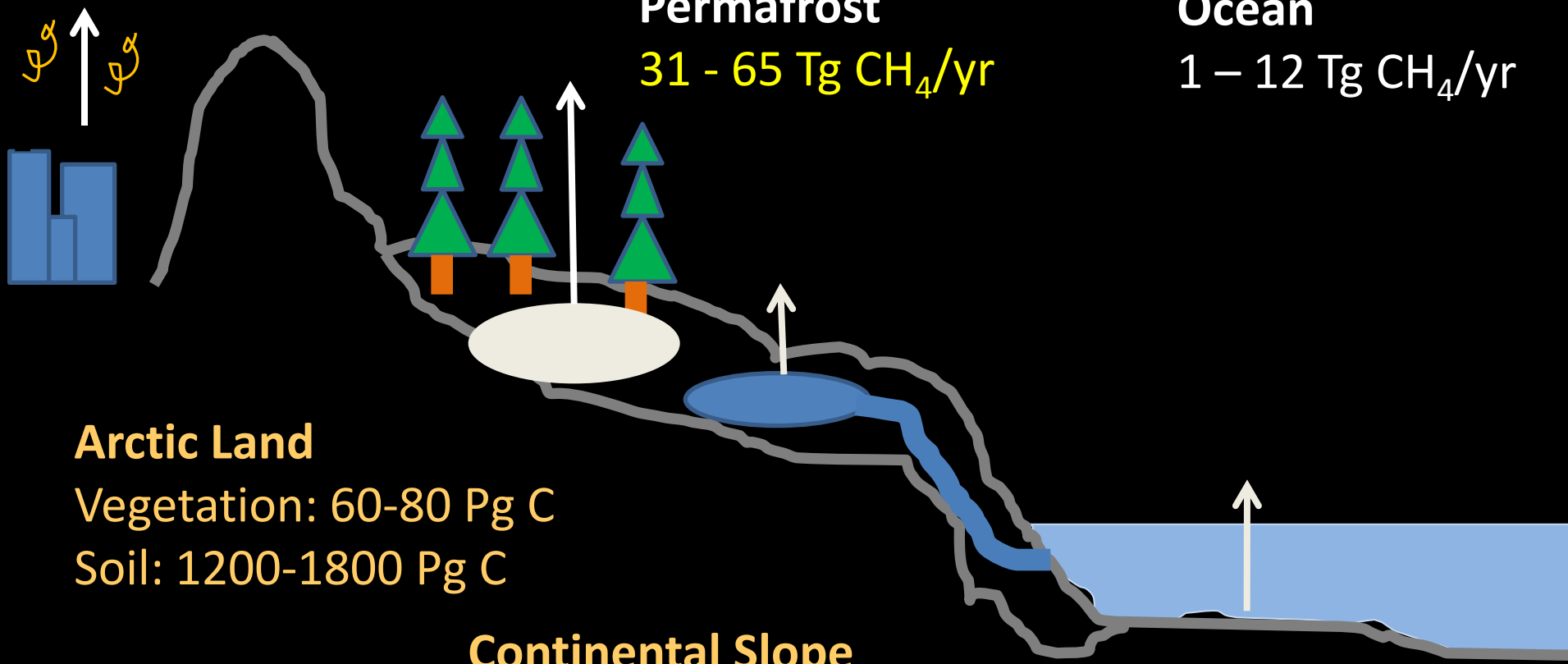
Waste: 5.3 - 7.5 Tg CH_4/yr

Terrestrial Ecosystem/ Permafrost

31 - 65 Tg CH_4/yr

Ocean

1 – 12 Tg CH_4/yr



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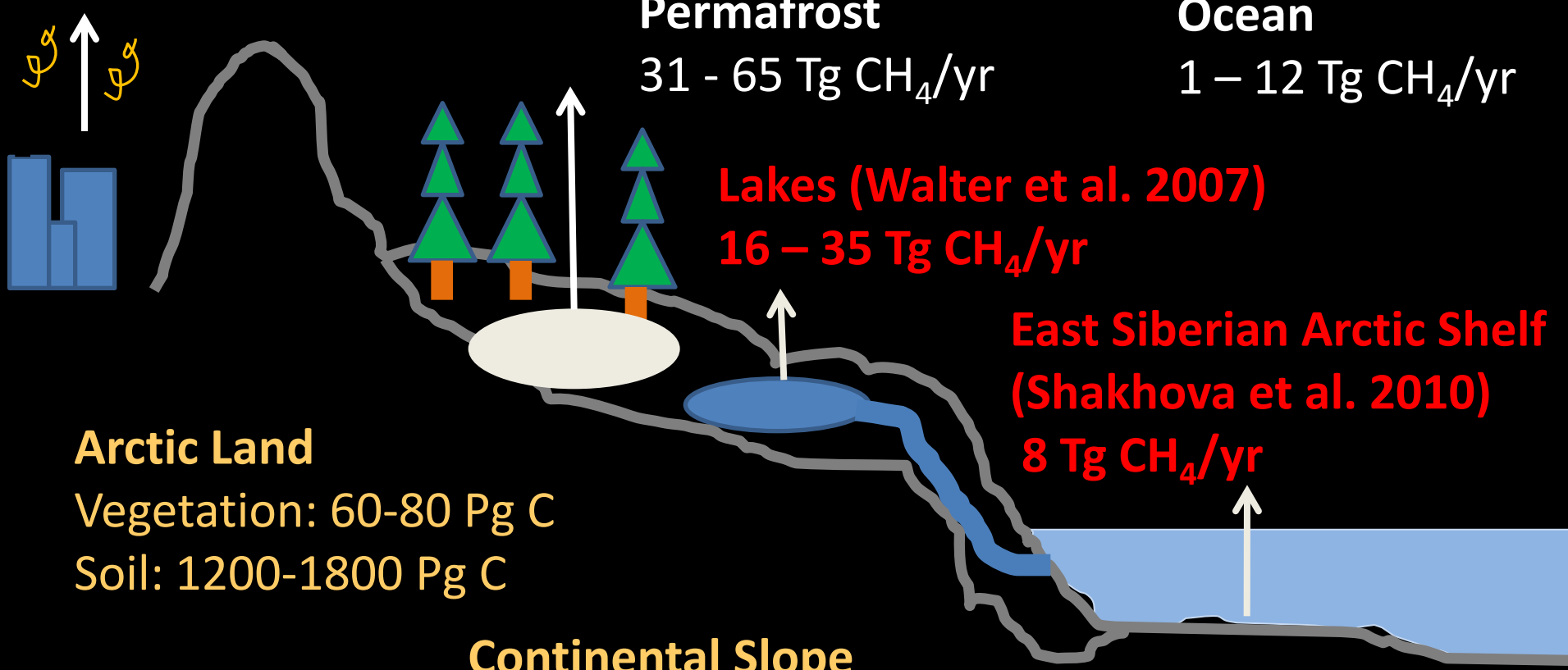

Lakes (Walter et al. 2007)

16 – 35 Tg CH_4/yr

East Siberian Arctic Shelf (Shakhova et al. 2010)

8 Tg CH_4/yr

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Vegetation: 60-80 Pg C

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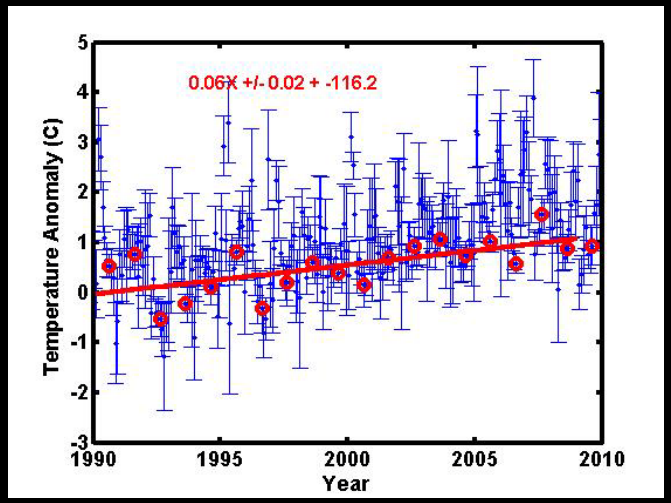
>.6 degree per decade



(GISS)

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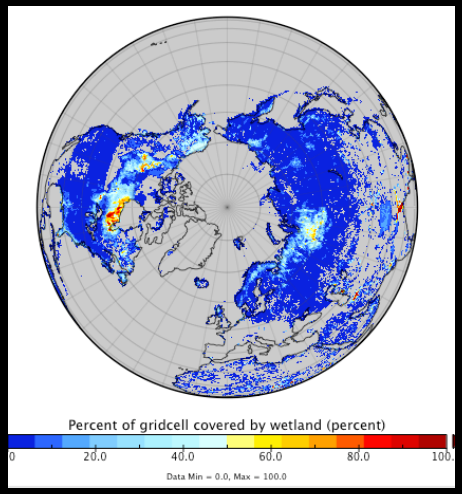

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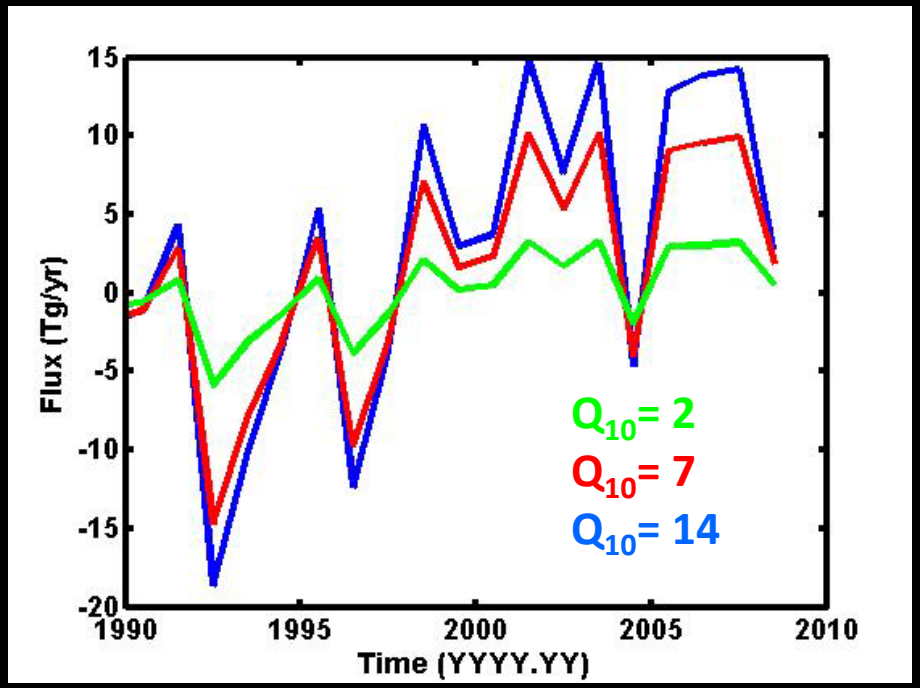
Bottom Up Estimates

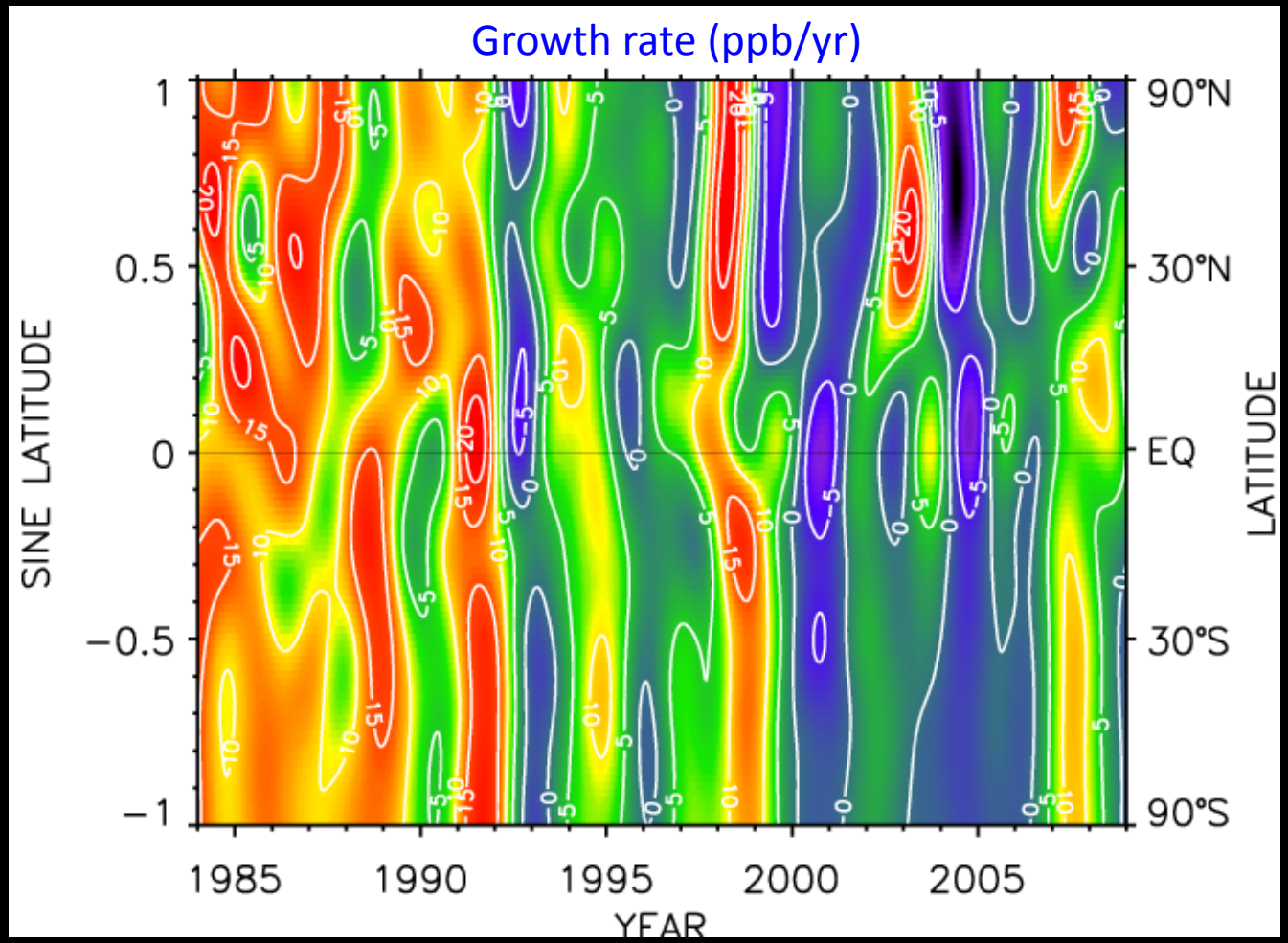
Wetland - Temperature



Wetlands (Matthews and Fung, 1987)

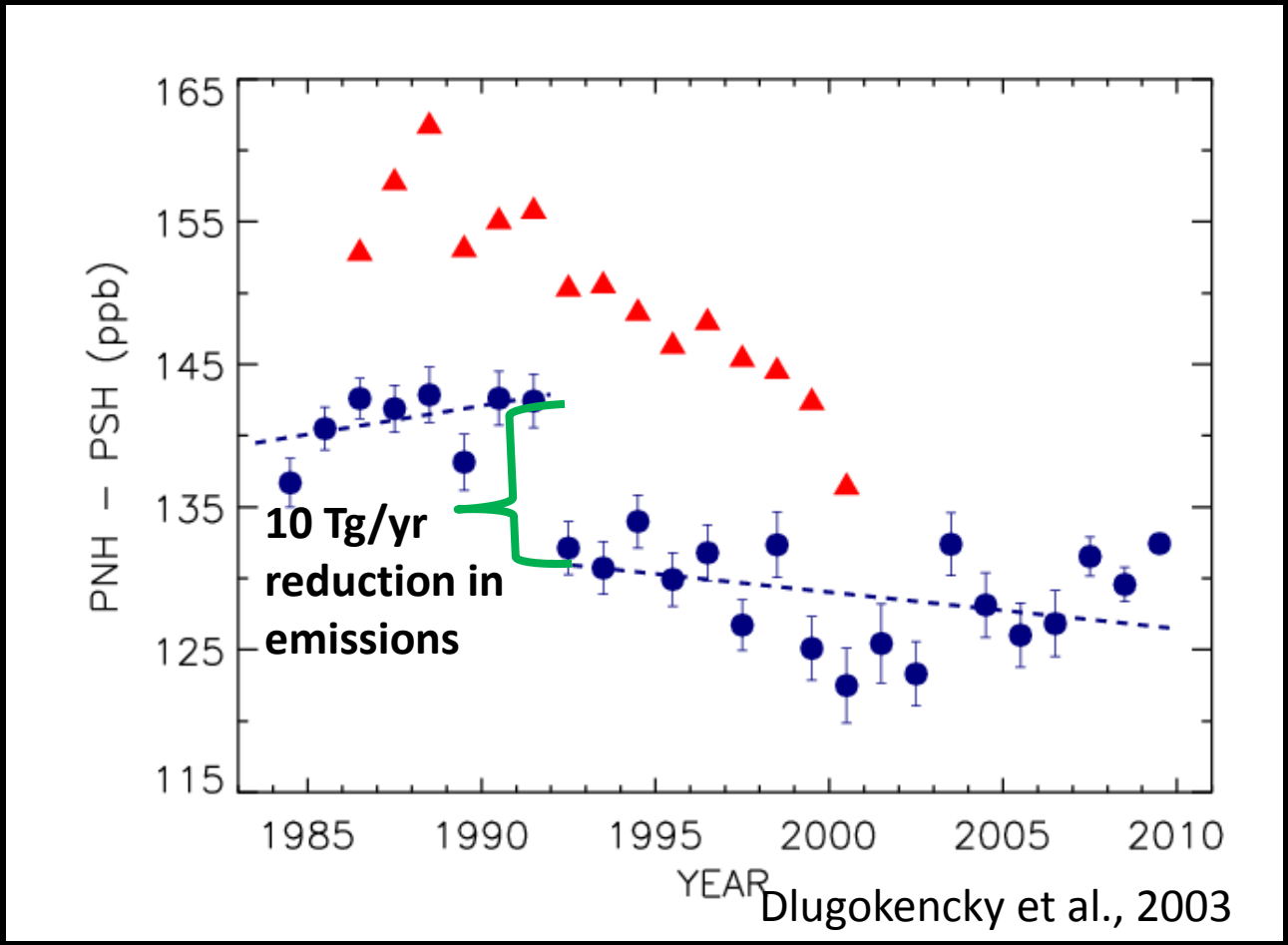
Top Down

Grow rate anomalies



- **No Trend**
- **1998, 2003, 2007 are high growth years in the Arctic**

Top Down
Inter polar difference



- **No upward trend**

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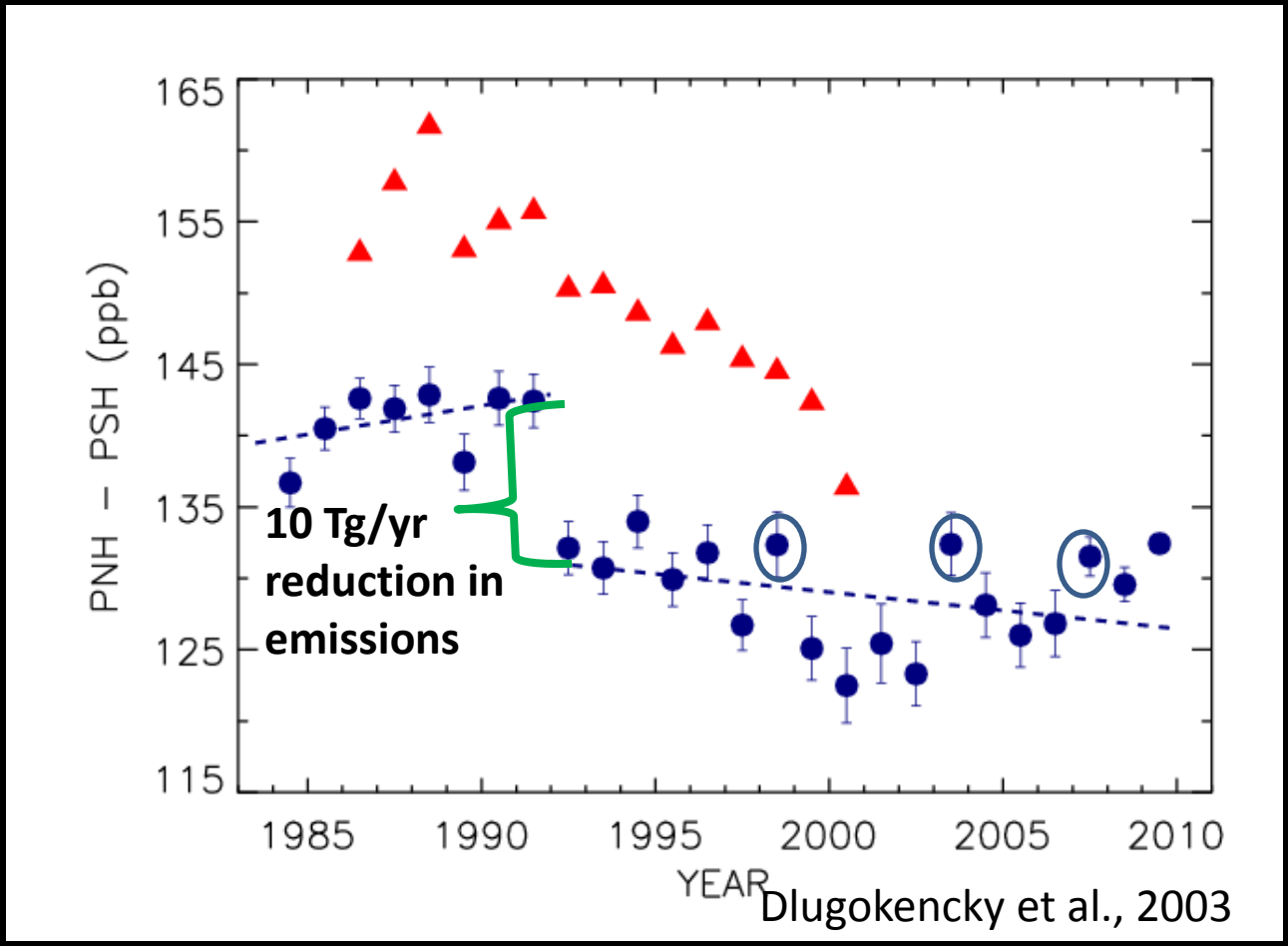
Inter polar difference



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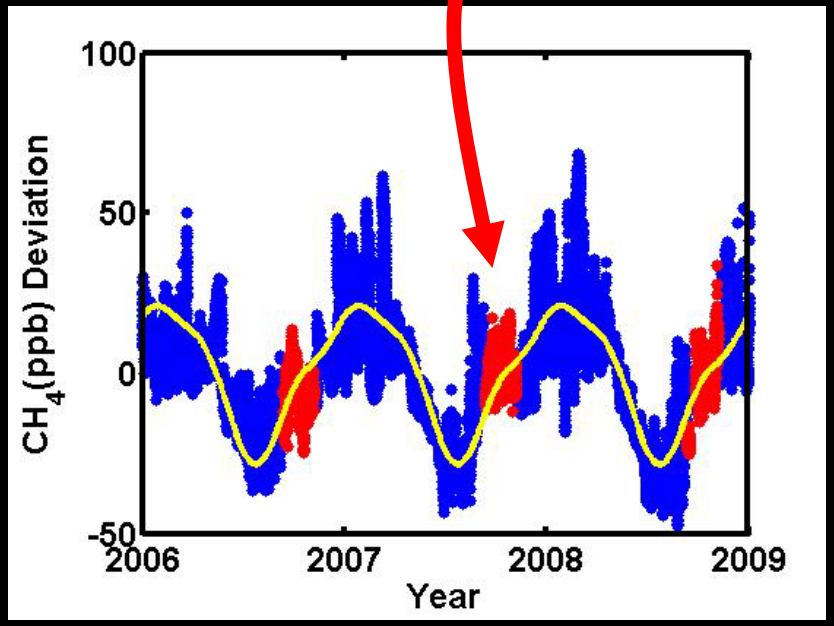
Top Down

Shoulder Analysis



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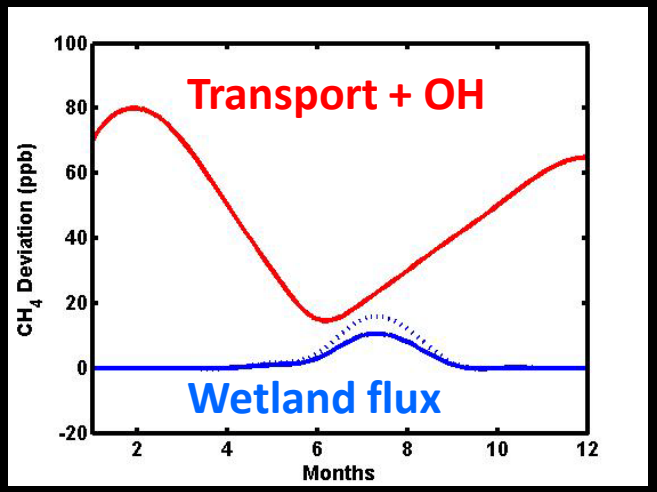
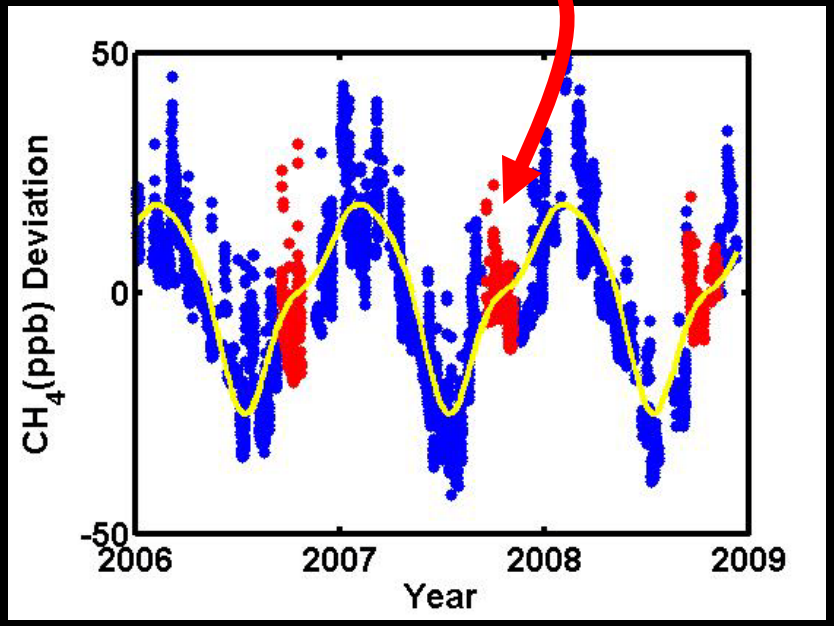
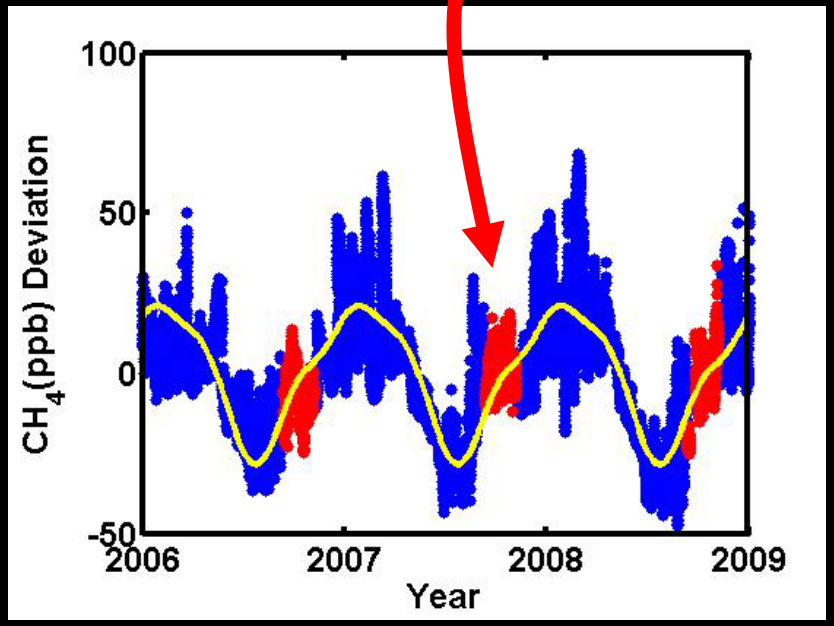




Barrow

Top Down

Shoulder Analysis



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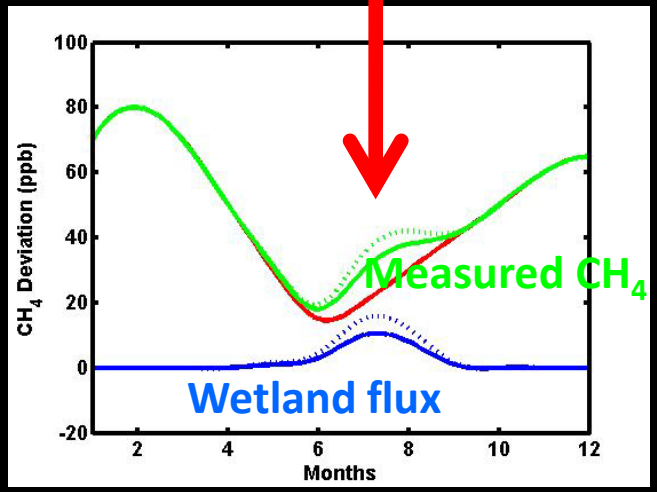

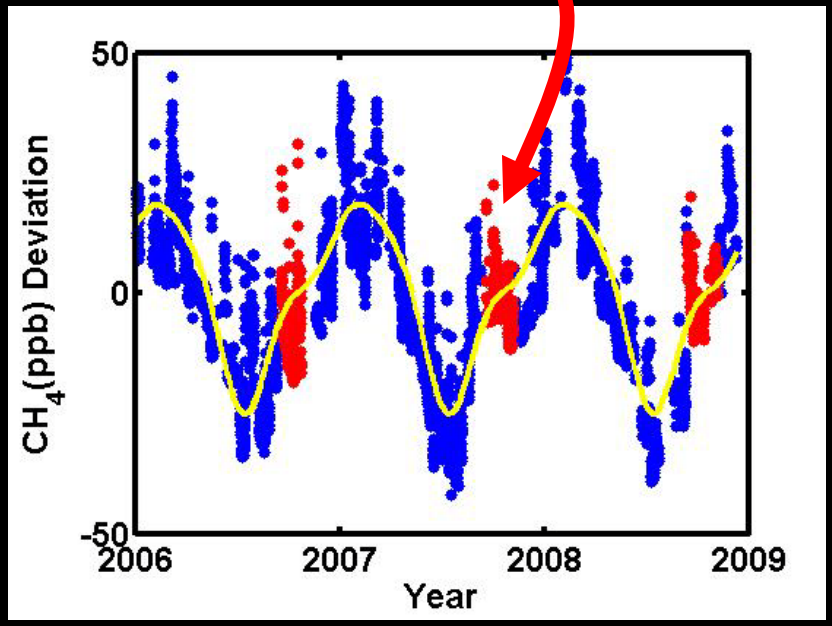

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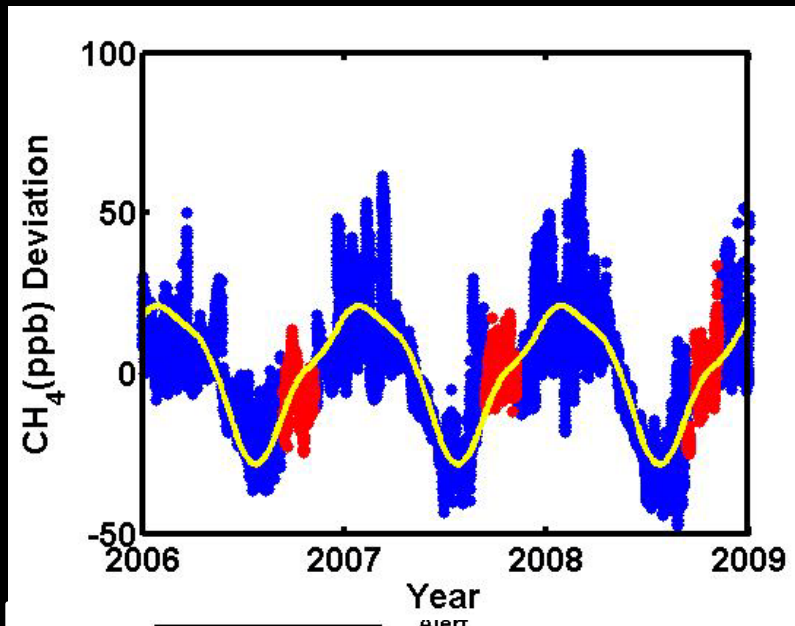
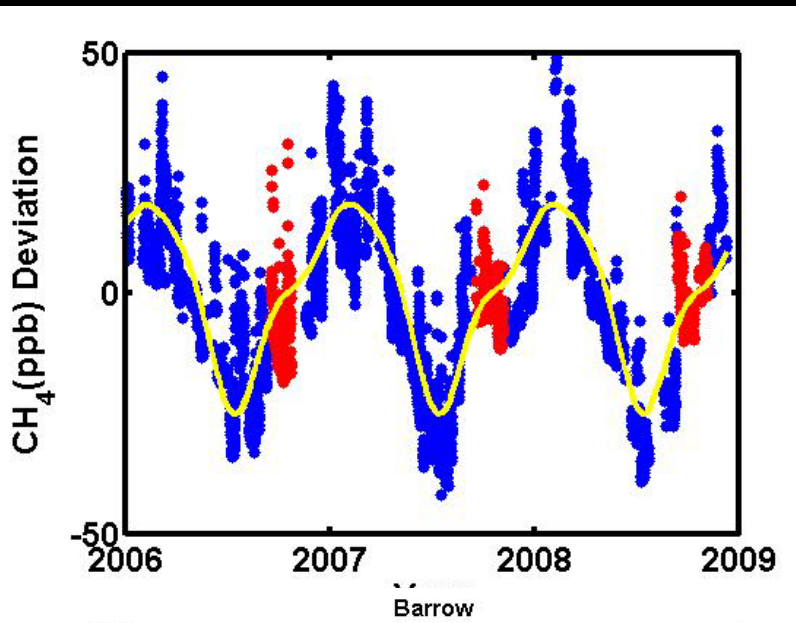
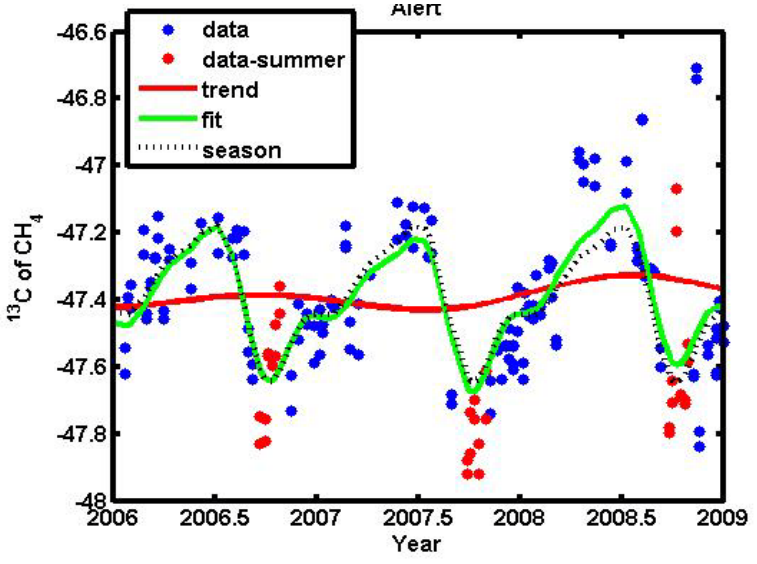
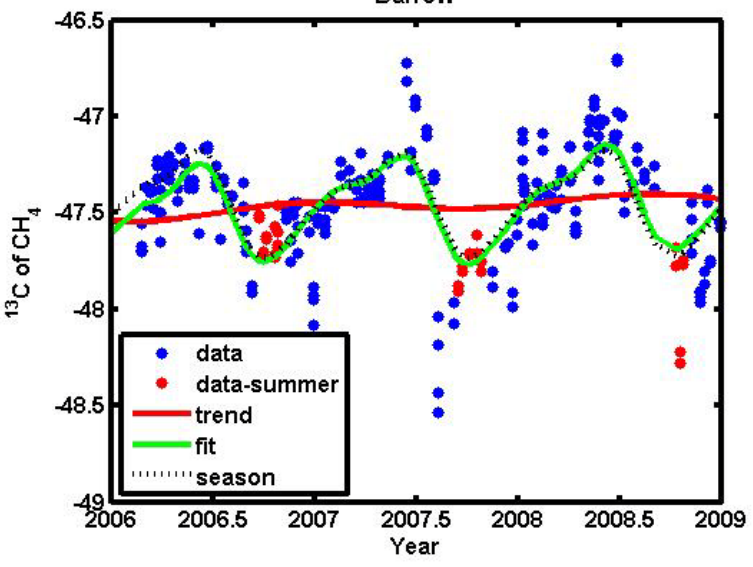


CH_4





$^{13}CH_4$



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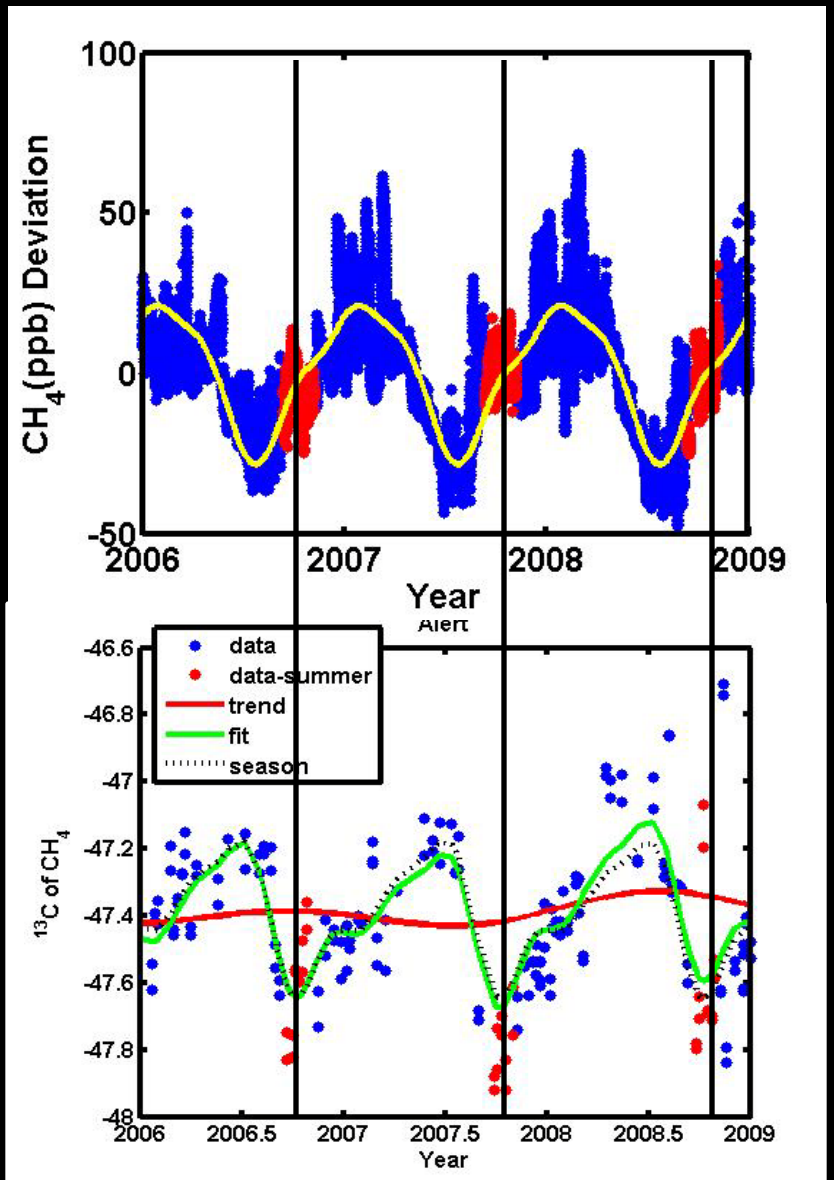

CH_4

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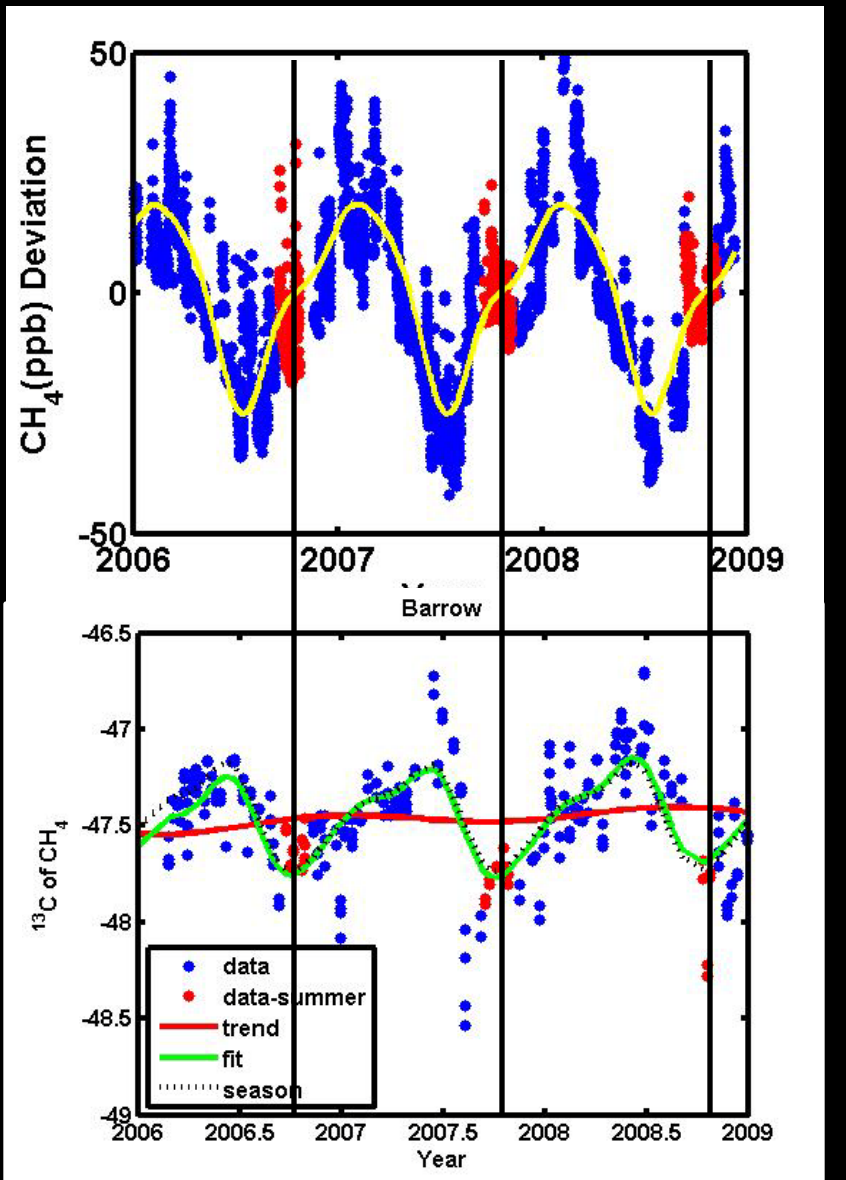
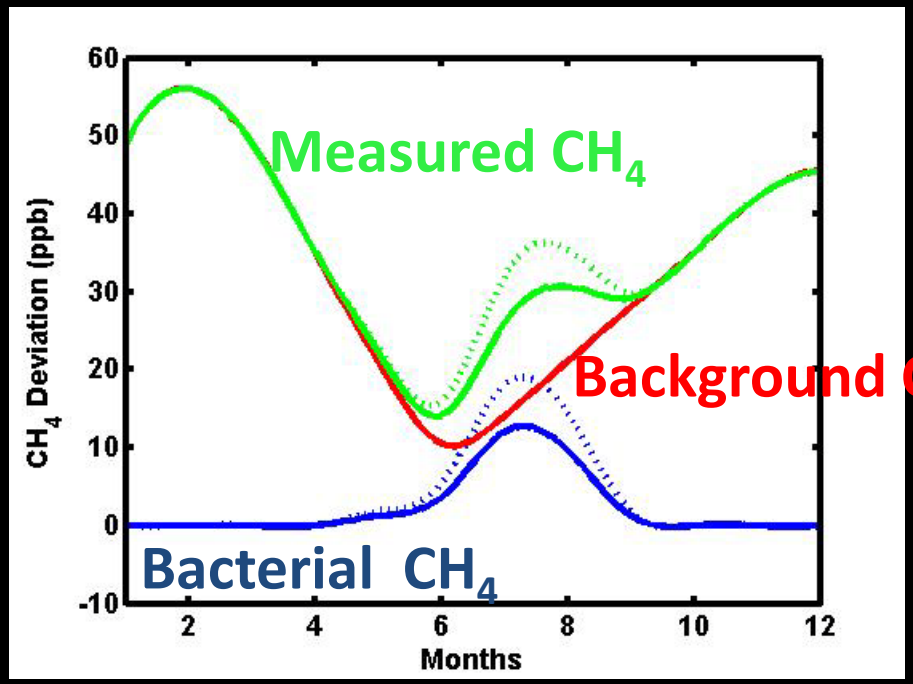
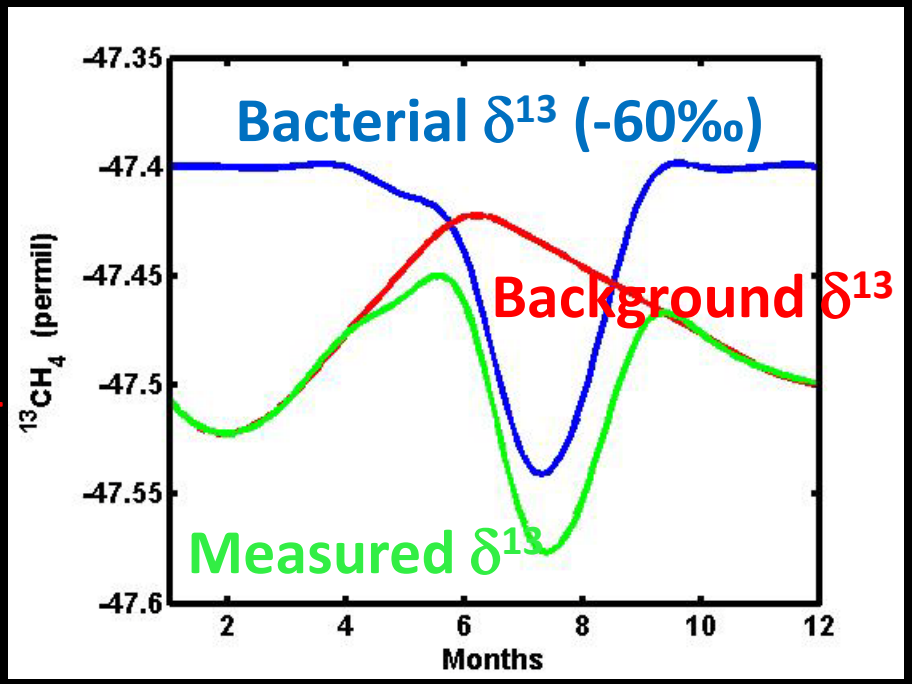


Simple model of $\delta^{13}CH_4$

CH_4 mixing ratio



$\delta^{13}CH_4$ (‰)



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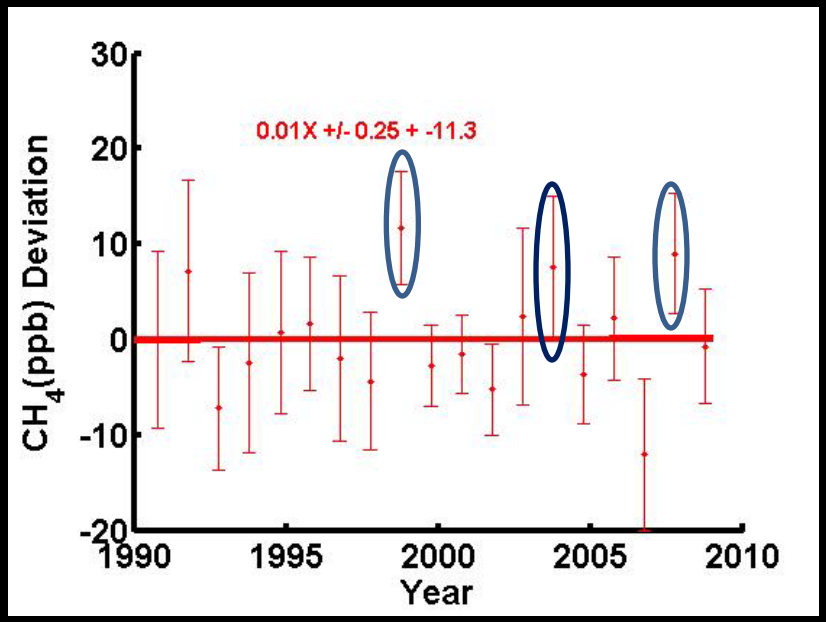

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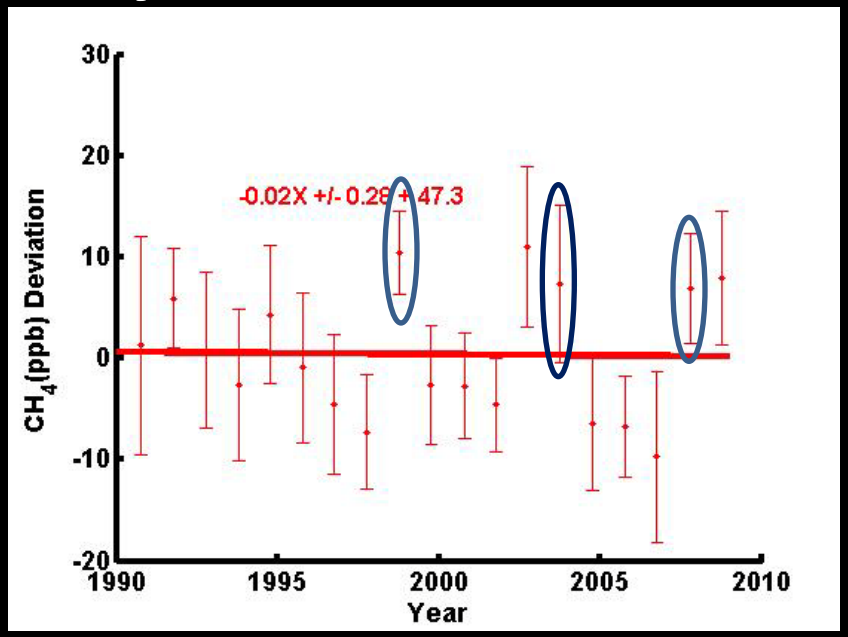


Barrow

- Peak years are consistent with other analysis
- No trend

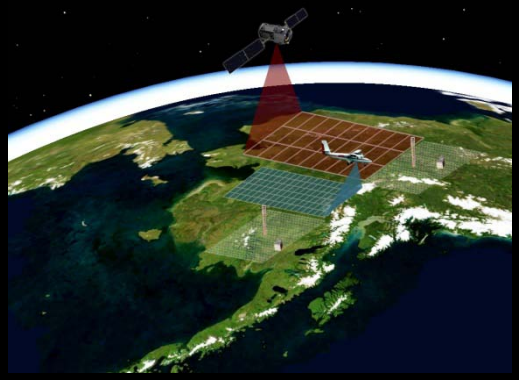
Conclusions

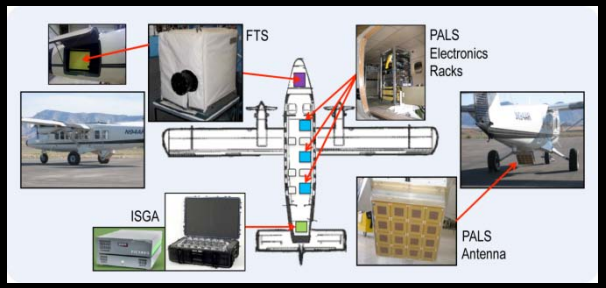
- **Budget** – Recent finding of large sources of methane in the arctic conflict with previous inversion estimates.
- **Climate change** - A top down analysis of methane in the Arctic does not indicate that there is a significant trend in methane out gassing in the Arctic despite observed increases in temperature.
- **Future work** – Isotopes and studies that integrate top down measurements with bottom up process studies are crucial.

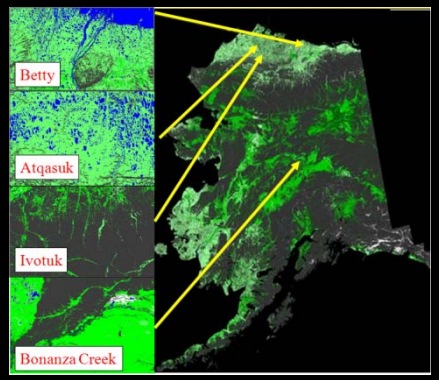
US Coast Guard (ACG)

CH_4, CO_2, CO, Ozone
Flask samples

Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE): An EV-1 Investigation







Principal Investigator : Charles Miller
Project Manager: Steve Dinardo
Implementation Center: JPL

Flights

- **Platform**: De Havilland DHC-6 Twin-Otter
- **Engineering test flights** start in April 2011
- **Science Operations**: Regular spring, summer and fall deployments annually 2012 – 2014 when arctic carbon fluxes are large and change rapidly

Instrument Payload

- L-band radar/radiometer
- Nadir viewing Fourier transform spectrometer
- Continuous in CO_2, CH_4 and CO
- Programmable flask packages (whole air sampling)

Measurements

- Surface parameters controlling carbon emissions: soil moisture, freeze/thaw state, inundation state, surface temperature
- Total atmospheric columns of CO_2, CH_4 and CO
- Atmospheric concentrations of CO_2, CH_4 and CO
- Ground-based measurements of $^{14}CO_2$ and $^{14}CH_4$

Earth Science Relevance

- High priority objectives across NASA's Carbon Cycle & Ecosystems, Atmospheric Composition, and Climate Variability & Change focus areas
- Air Quality and Ecosystems elements of Applied Sciences Program

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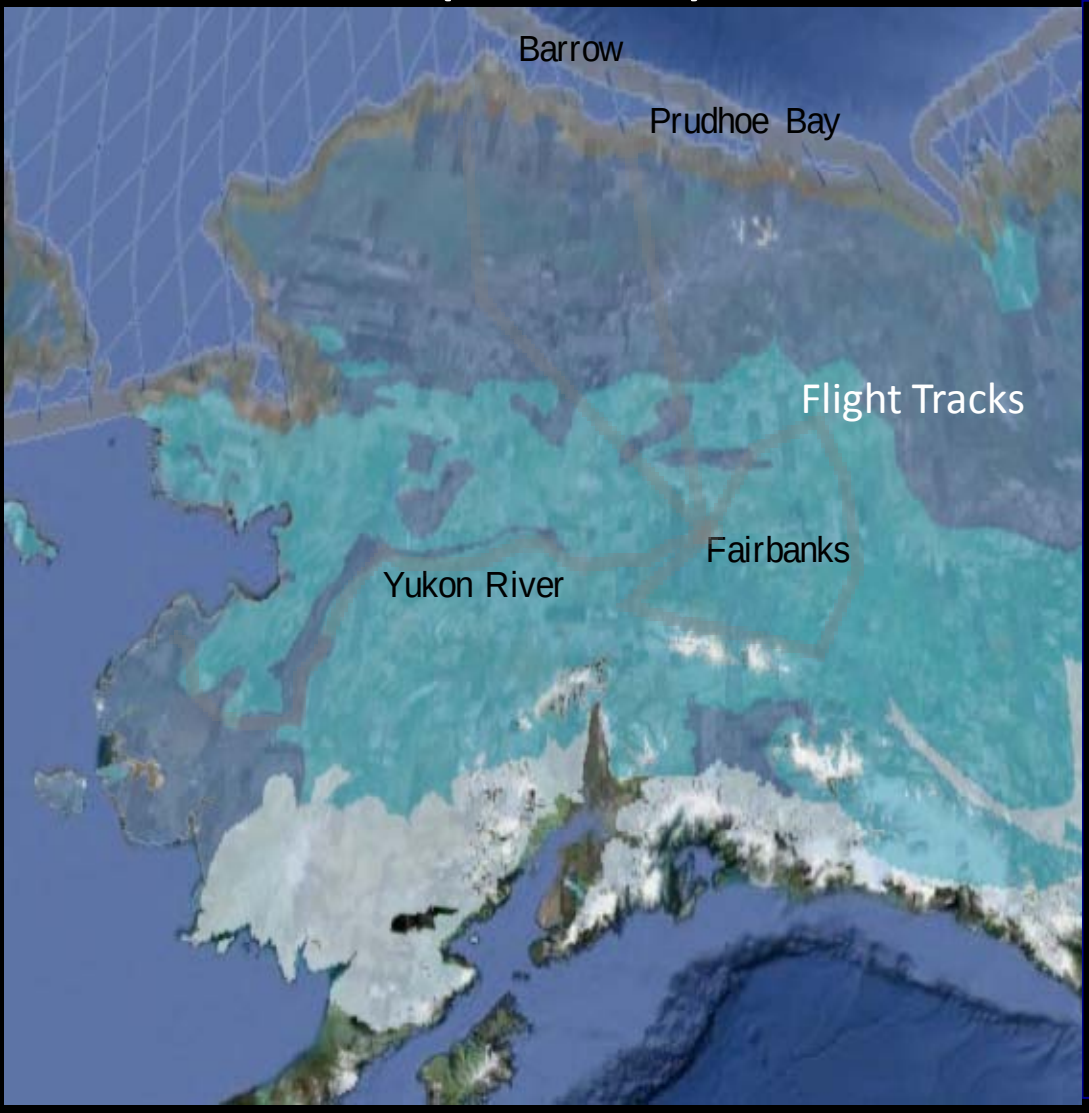

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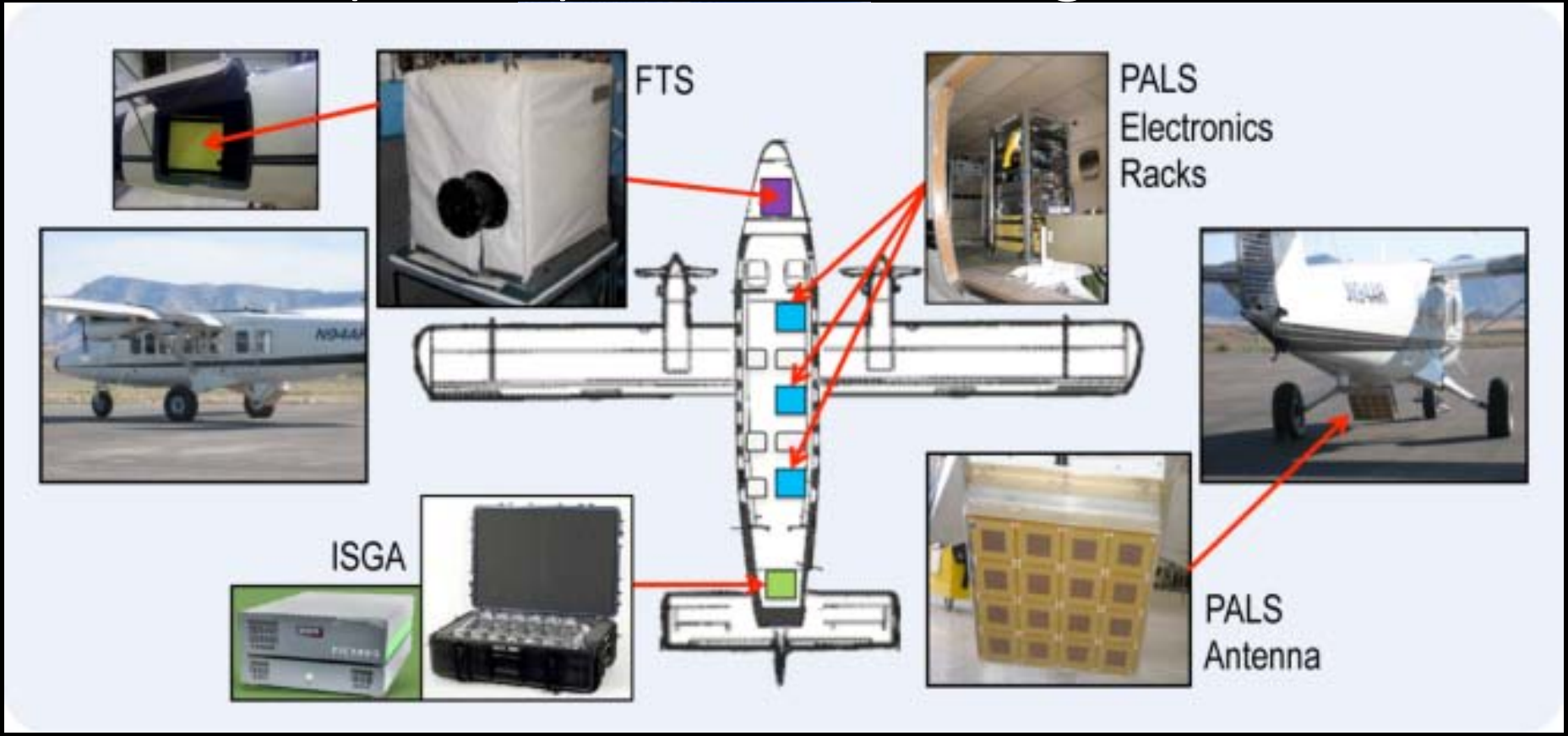


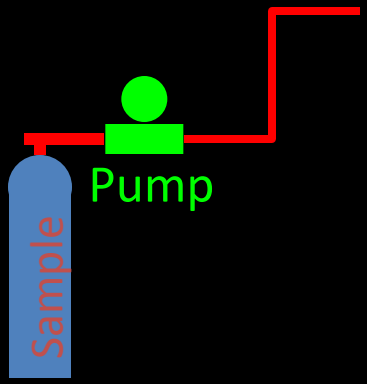
PALS - L-band radar/radiometer –soil moisture, freeze/thaw state, inundation state, surface T

FTS - Nadir viewing Fourier transform spectrometer - Total atmospheric columns of CO_2, CH_4 and CO

PFP/Picarro - In situ and flask samples – CO_2, CO, CH_4

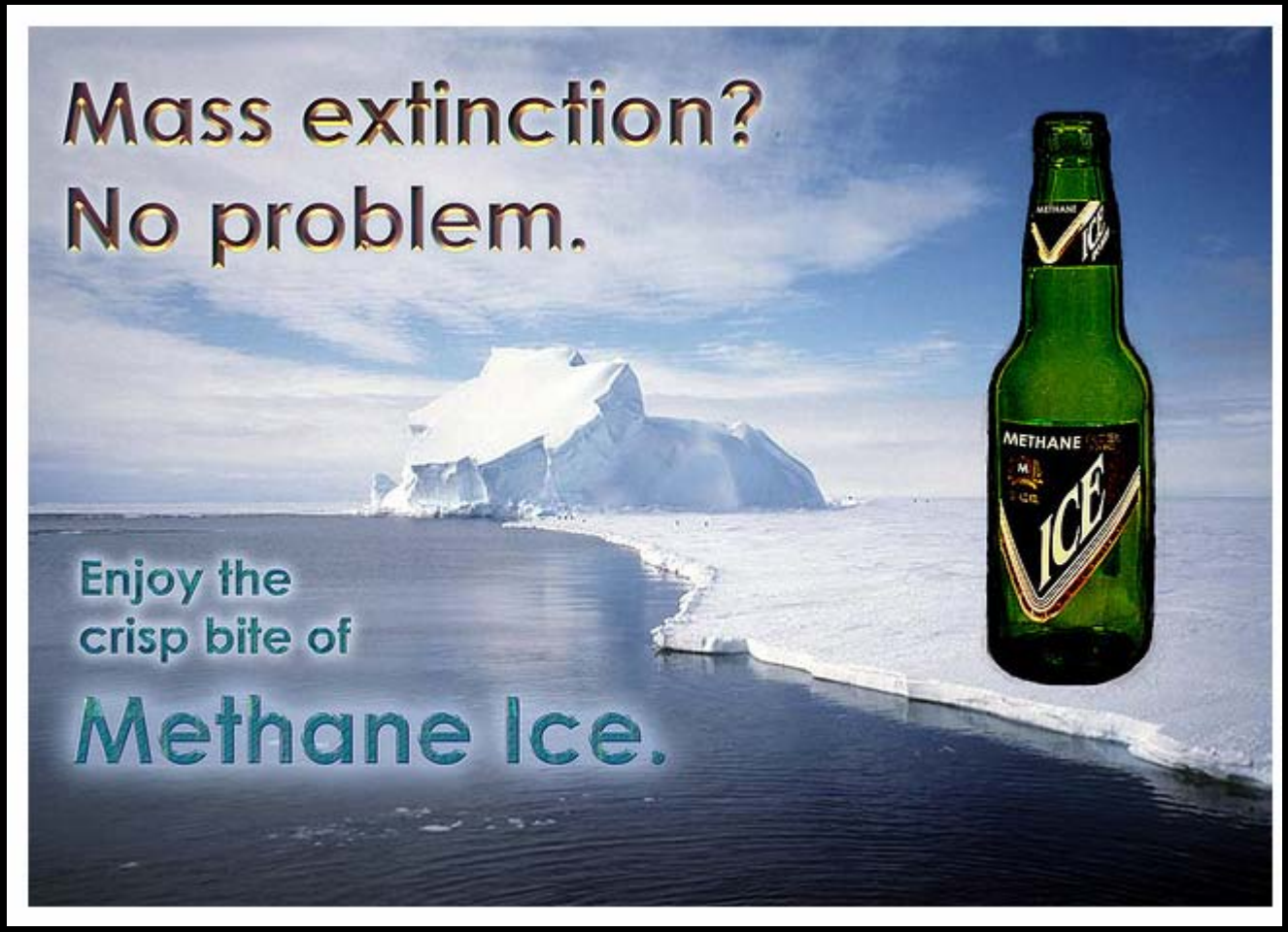
West Collimation Tower

12 flask package

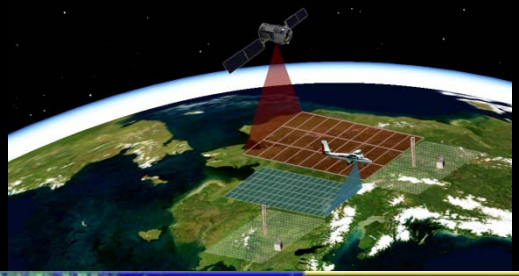


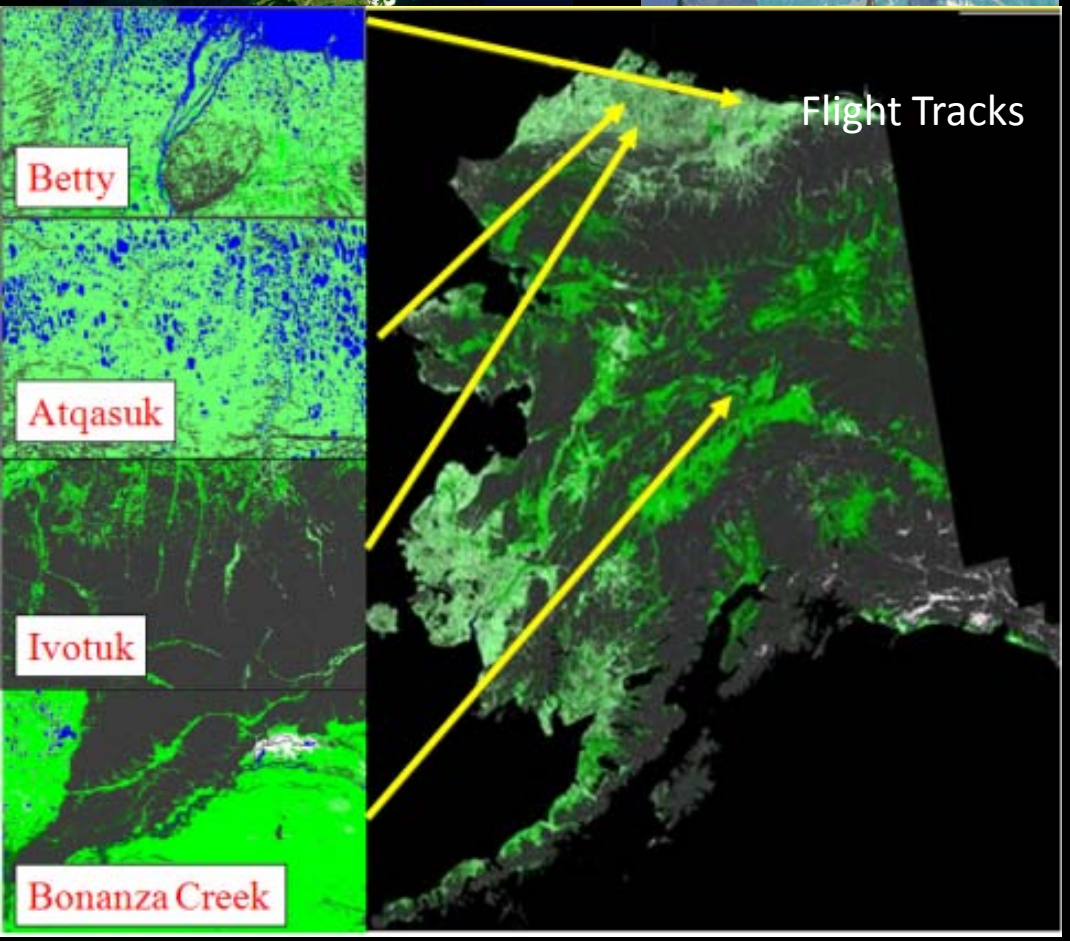
$^{14}CH_4$,$^{14}CO_2$ Sampling

Picarro CO2/CH4/CO/H2O analyzer


Mass extinction?
No problem.
Enjoy the
crisp bite of
Methane Ice.
METHANE
ICE

Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE): An EV-1 Investigation





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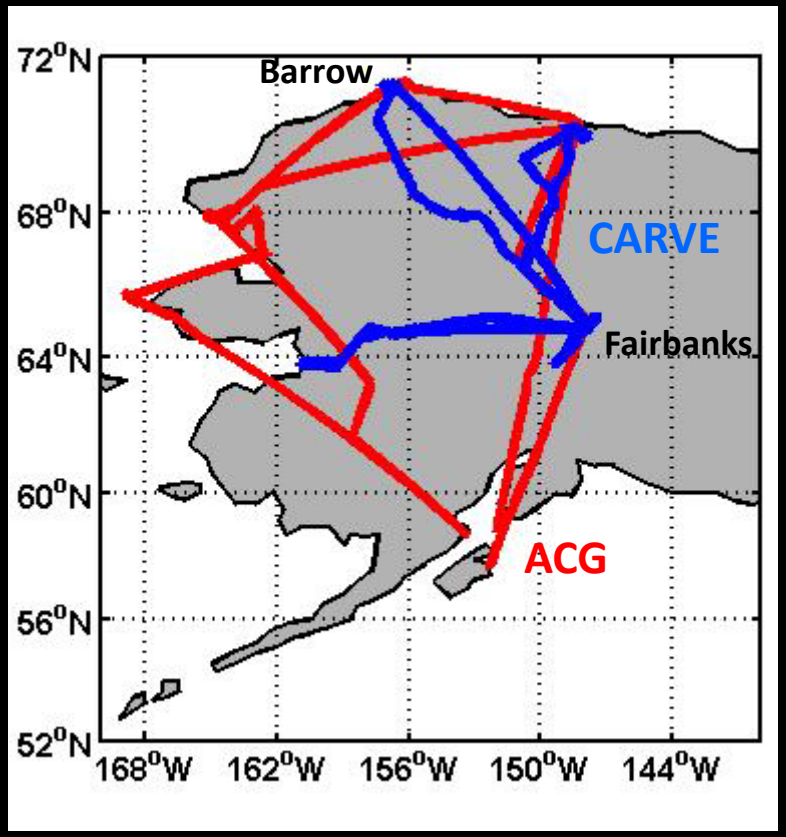
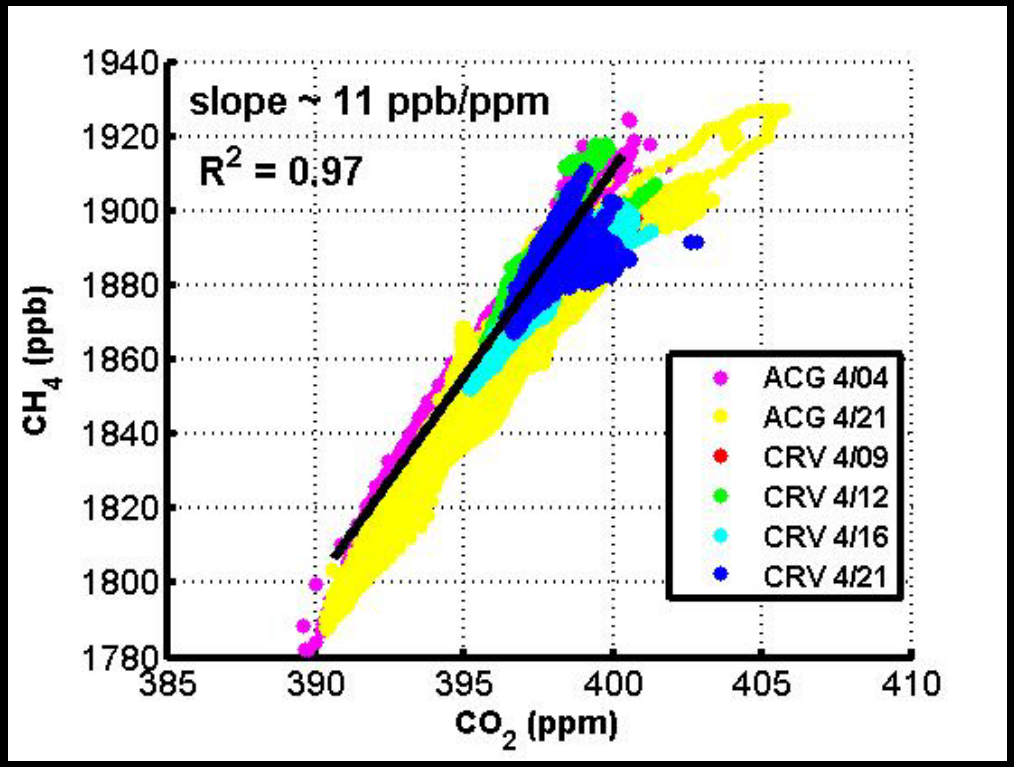
Comparison with Alaska Coast Guard (ACG) Flights (NOAA/ESRL)

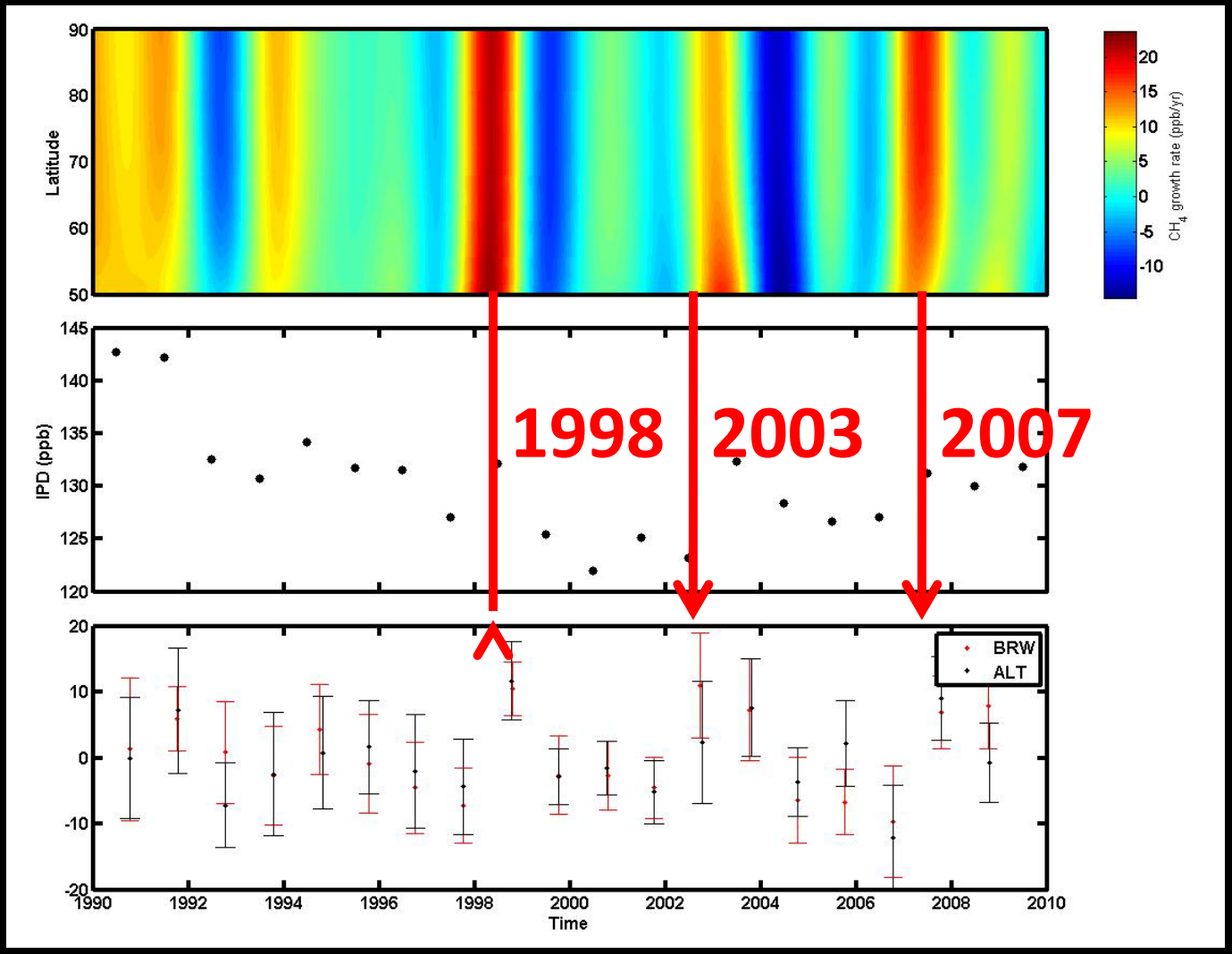


Flight Tracks ACG CARVE



CO_2:CH_4 correlation

Summary


Latitude
IPD (ppb)
Time
1998
2003
2007
BRW
ALT
CH4 growth rate (ppb/yr)