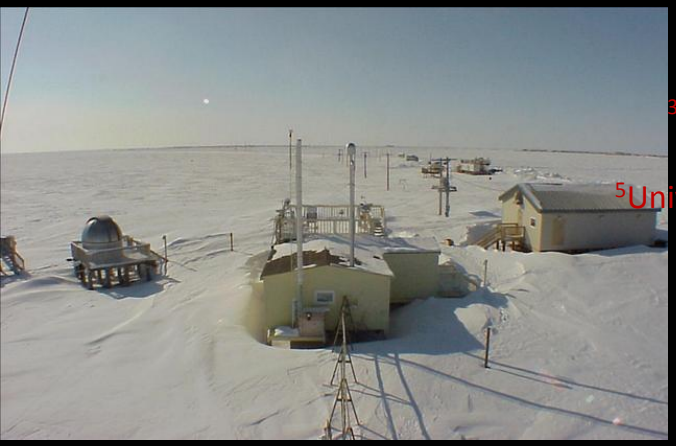
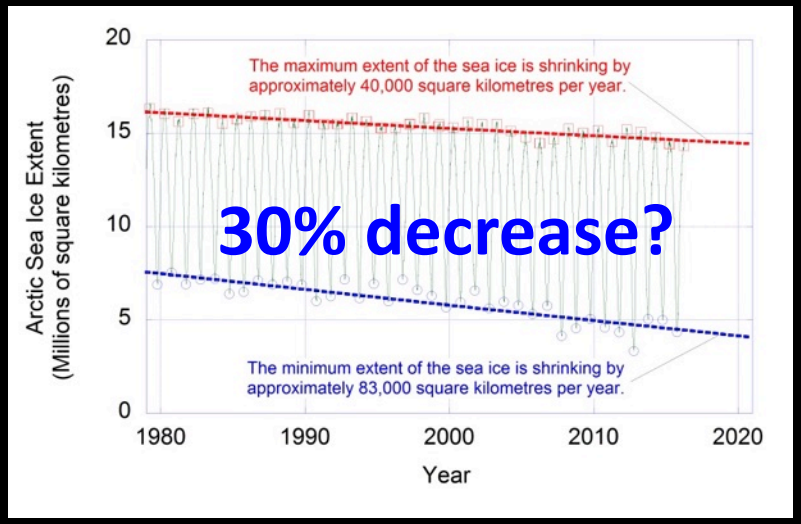
Measuring the effects of Arctic climate change: CH_4 emissions at the NOAA Point Barrow Observatory

Colm Sweeney[1,2], Ed Dlugokencky[2], Charles Miller[3], Steve Wofsy[4], Anna Karion[1,2,*], Steve Dinardo[3], Rachel Y.-W. Chang[5], John Miller[2], Lori Bruhwiler[2], Andrew Crotwell[1,2], Tim Newberger[1,2] Kathryn McKain[1,2], Robert Stone[1], Diane Stanitski[2], Sonja Wolter[1,2], Patricia Lang[2], Pieter Tans[2]

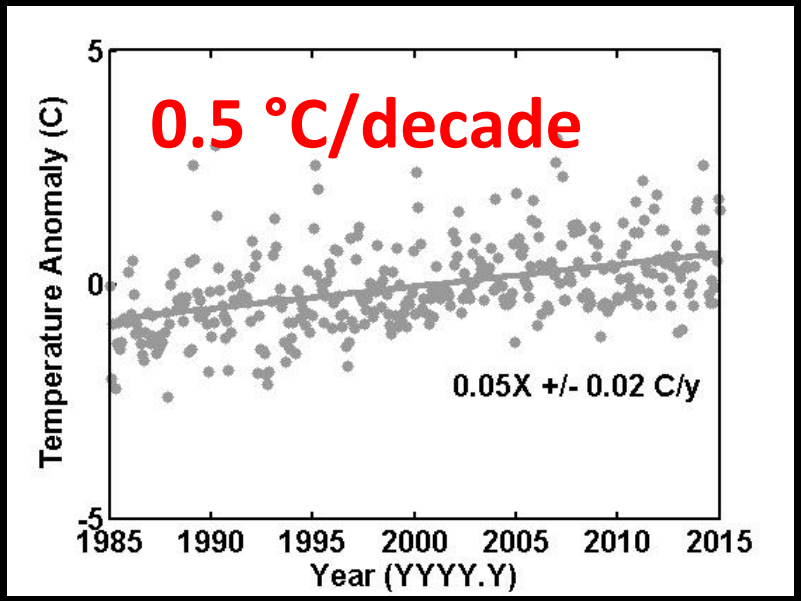
[1]University of Colorado, Boulder CO, 80309
[2]NOAA/ESRL, Boulder CO, 80305
[3]Jet Propulsion Lab, NASA, Pasadena, CA 91109
[4] Harvard University, Cambridge MA, 02138
[5]University of Dalhousie, Halifax, Nova Scotia, B3H 4R2 Canada



Evidence of rapid climate change in Arctic



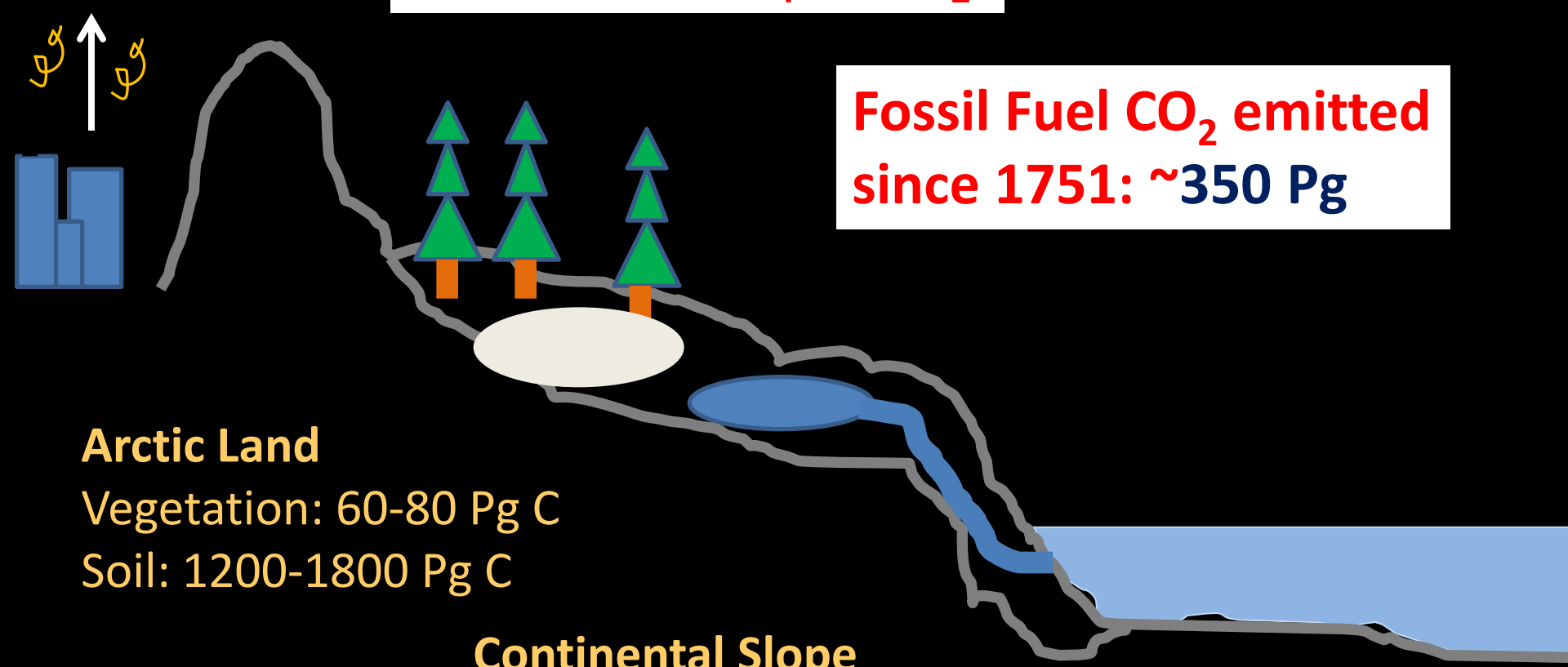
Sea Ice Extent (NSIDC 2016)



Land Temperature (NASA/GISS 2015)

Arctic Reservoirs

>1000 PgC could be released as CH_4 or CO_2



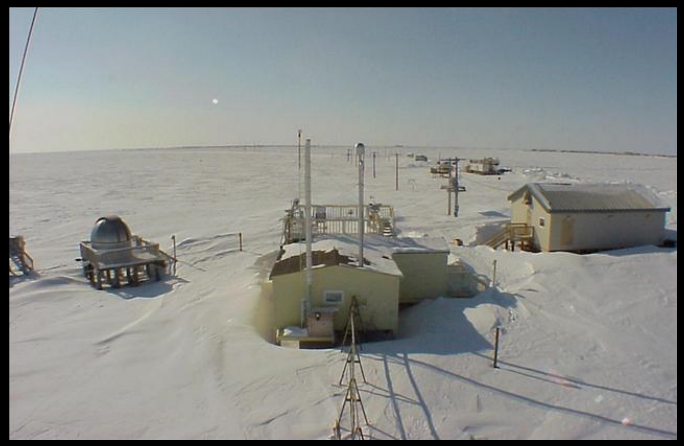
Fossil Fuel CO_2 emitted since 1751: ~350 Pg

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

Barrow Observatory



1973 - Present

Aerosols - insitu

Meteorology – winds, temp

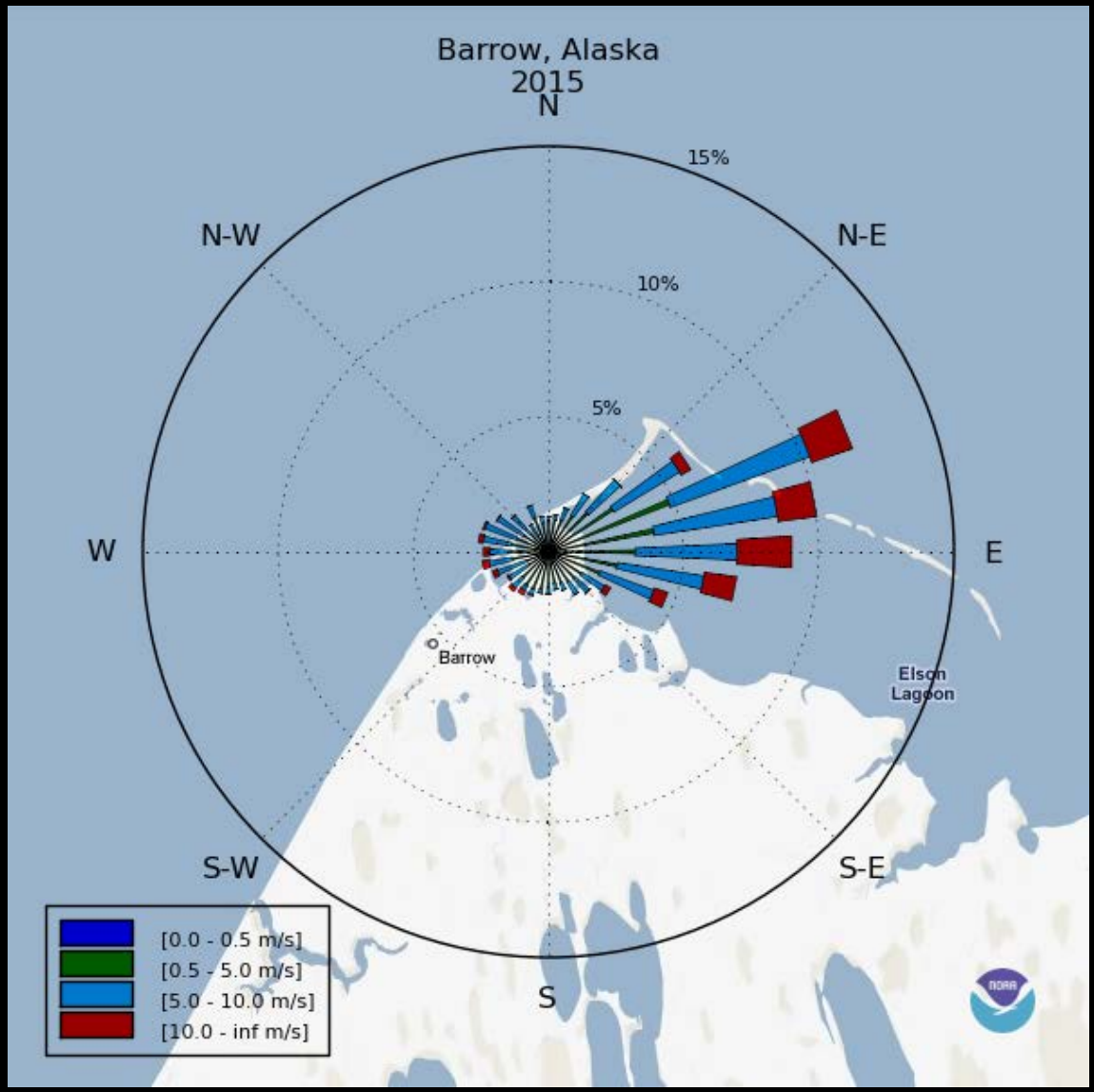
Halocarbons – Insitu, CFC, Chloroform etc.

GHG Gases – Insitu/flasks CO_2, CH_4, N_2O, CO, etc.

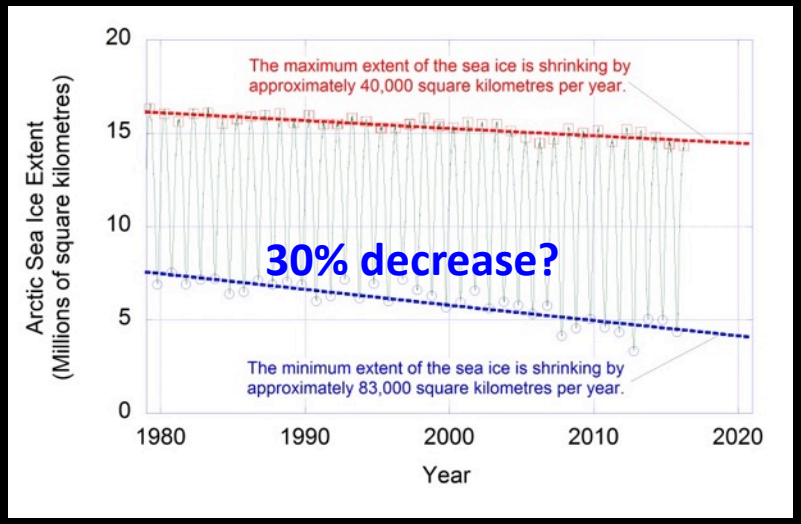
Hydrocarbons – ethane -> pentane

Ozone – Insitu

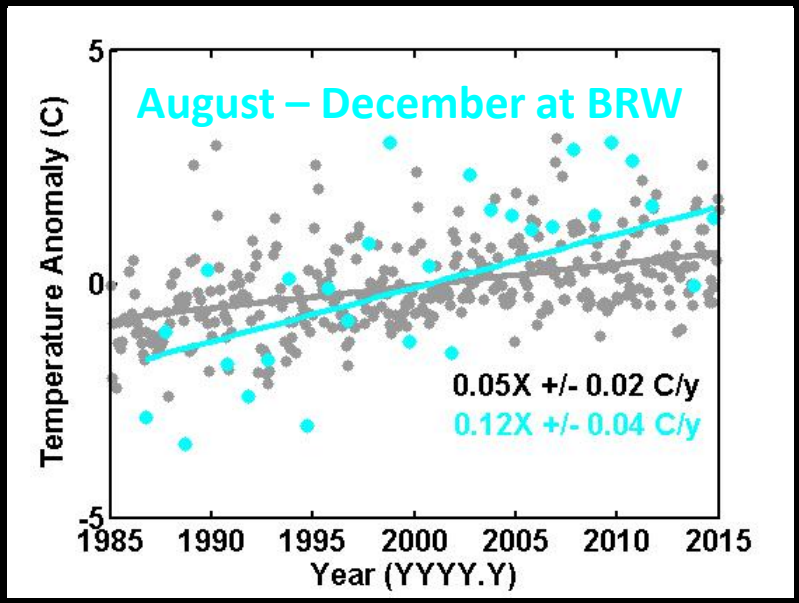
Radiation – albedo



Evidence of rapid climate change in Arctic

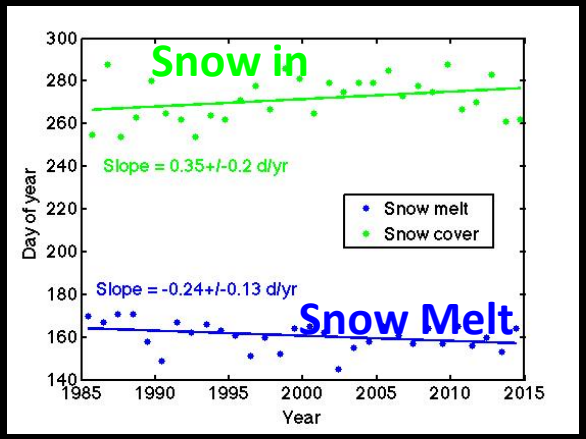


Sea Ice Extent (NSIDC 2016)



Land Temperature (NASA/GISS 2015)

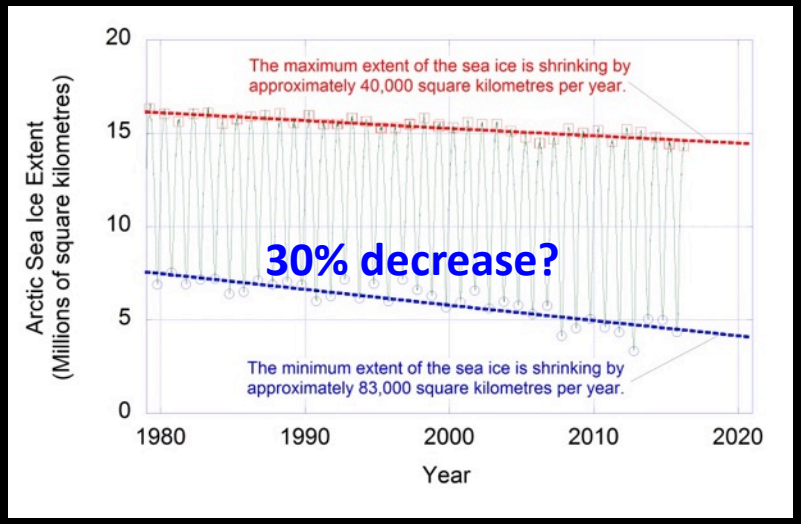
0.5 →1.2°C/decade



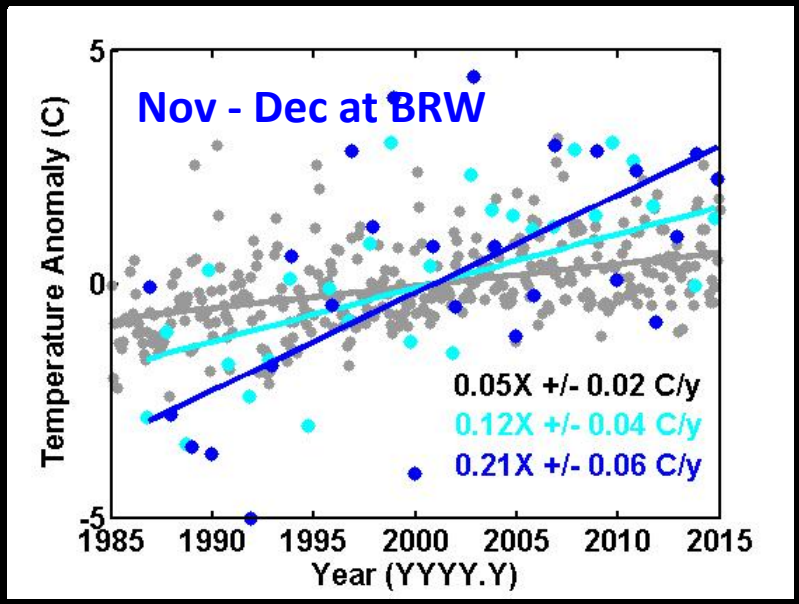
Snow Cover (Stone/Stanitski)

~20 day increase in days without snow

Evidence of rapid climate change in Arctic

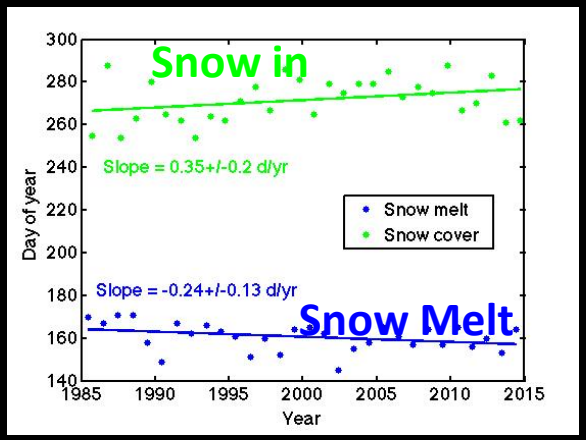


Sea Ice Extent (NSIDC 2016)



Land Temperature (NASA/GISS 2015)

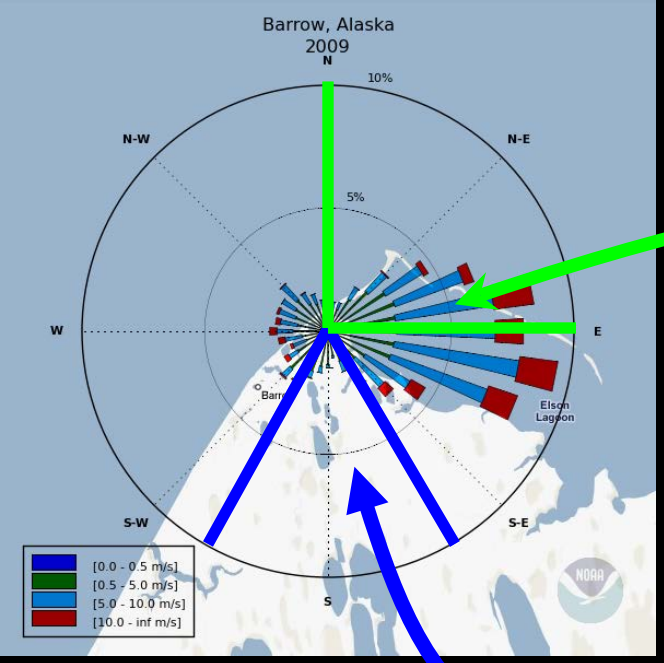
2.1°C/decade

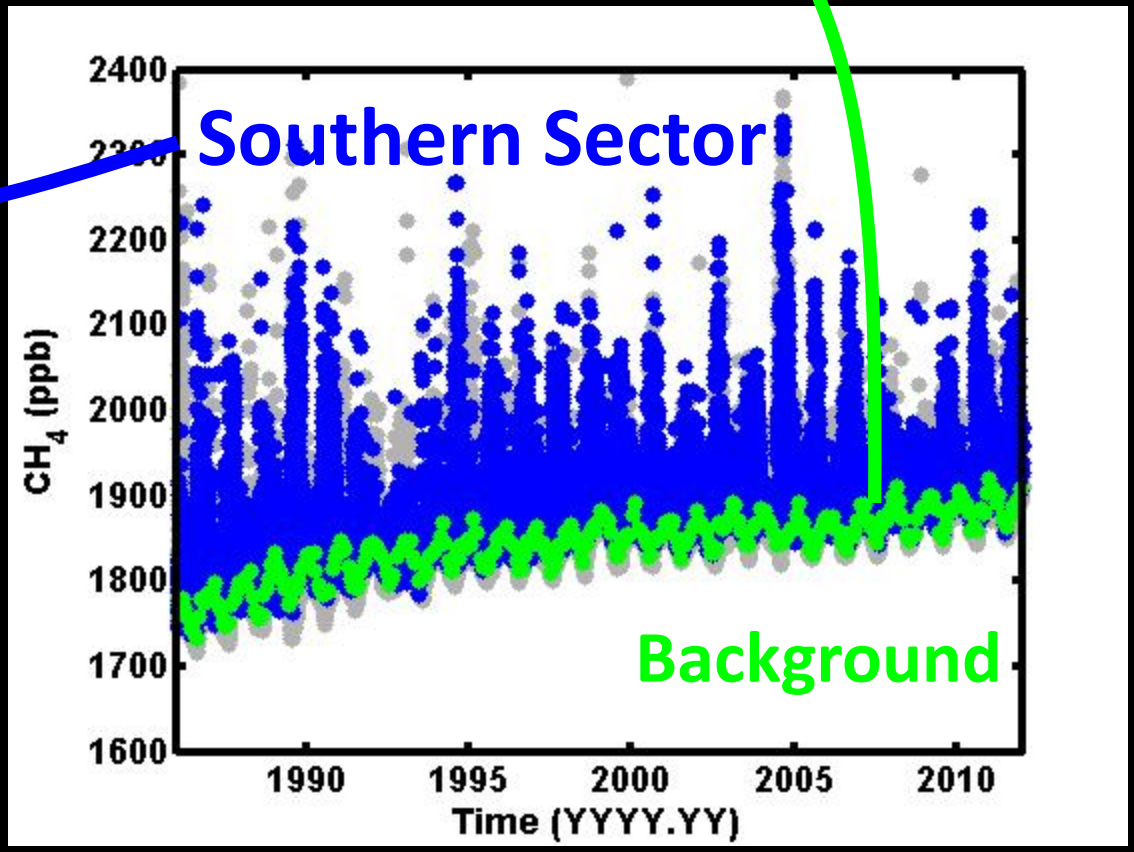


Snow Cover (Stone/Stanitski)

~20 day increase in days without snow (in past 30 years)

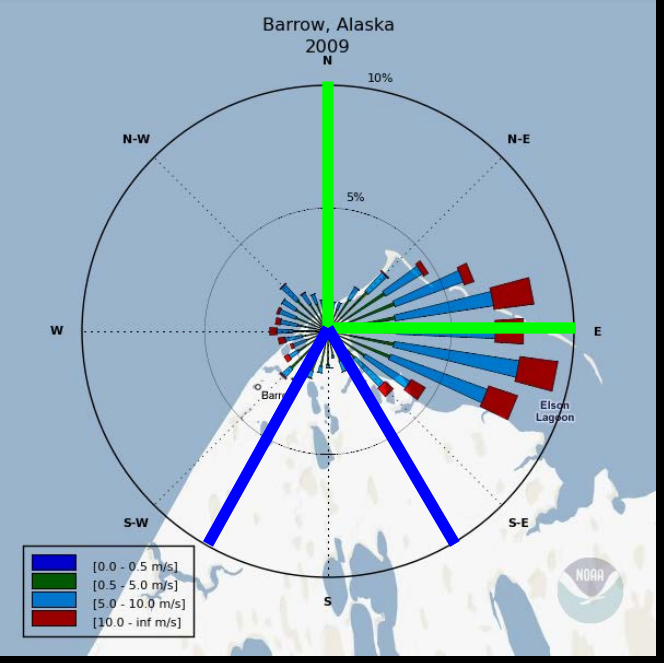
CH_4 at Barrow Observatory





Southern sector shows consistent enhancement above background

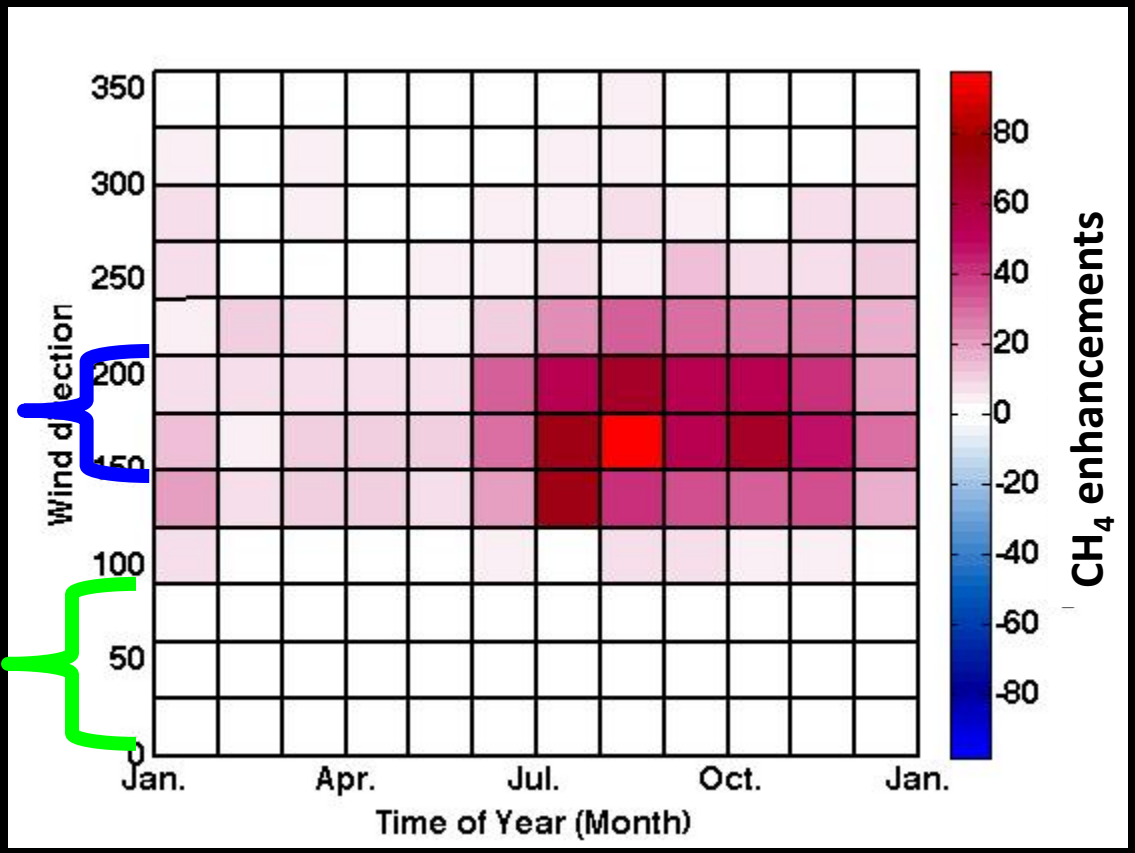
CH_4 at Barrow Observatory



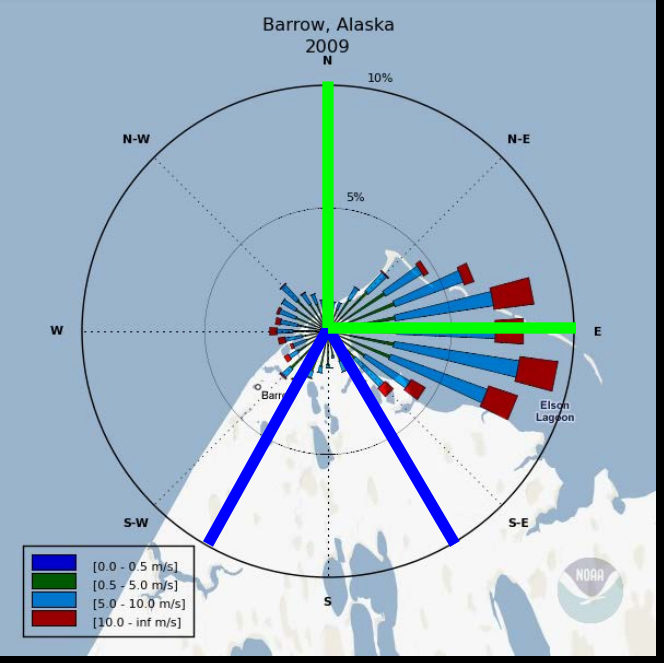
Average enhancements of >70 ppb from southern sector in late summer.

Land sector

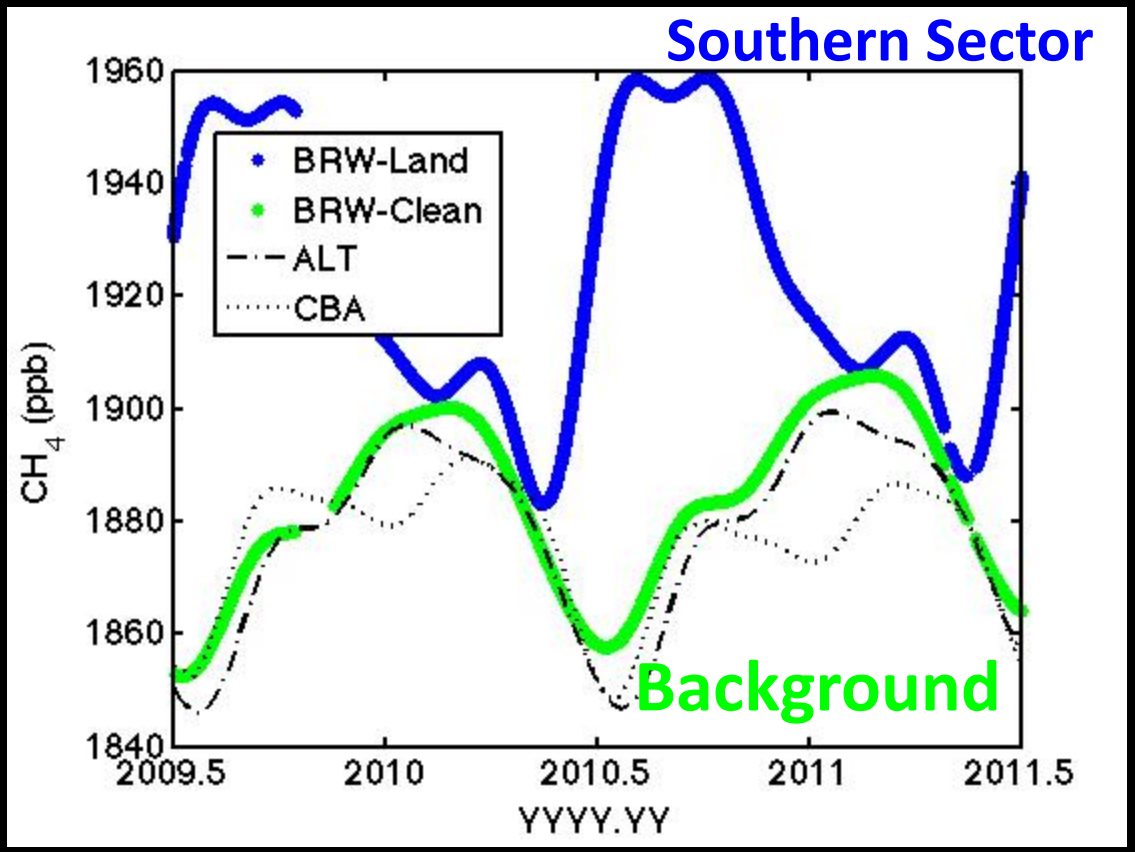
Clean air sector



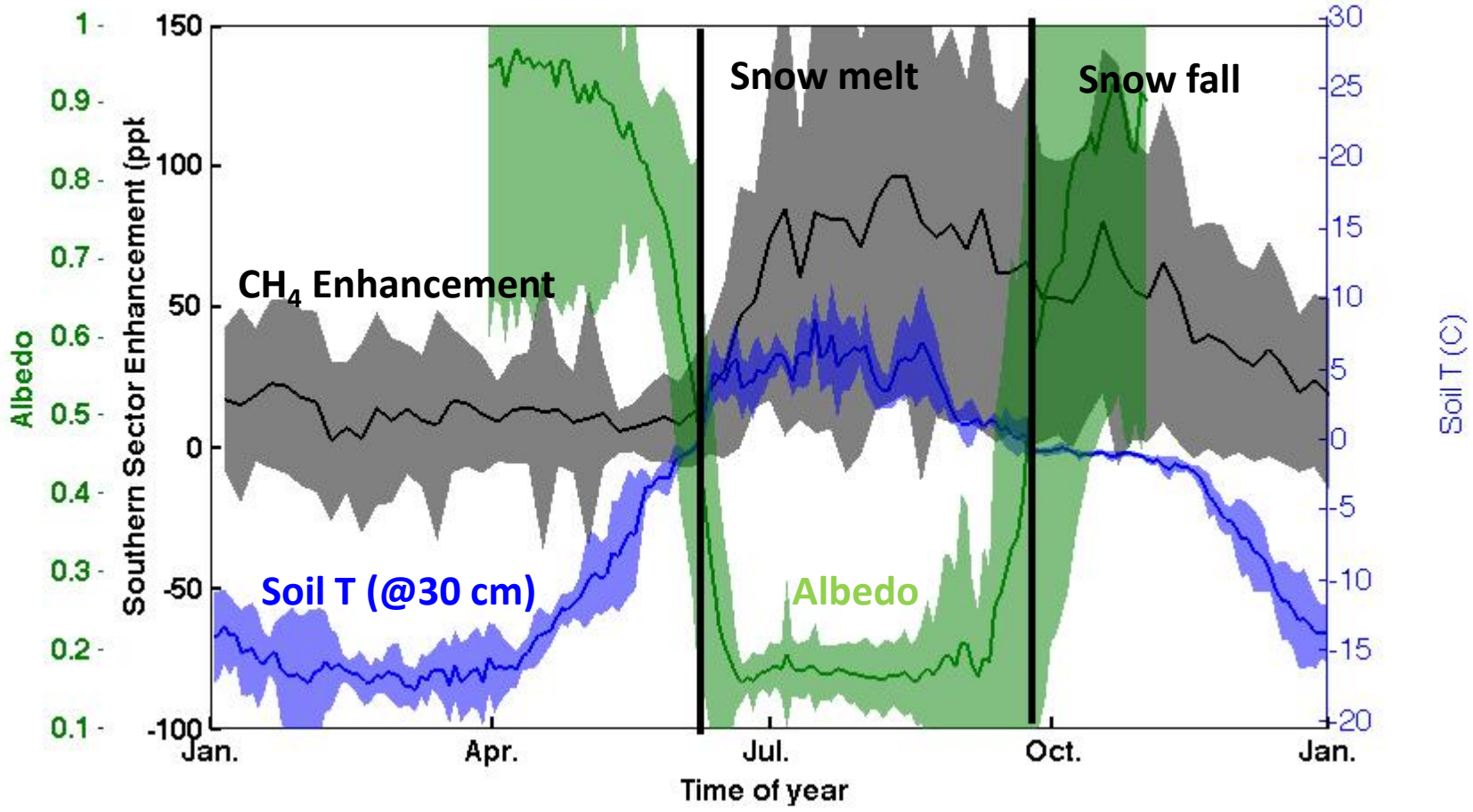
CH_4 at Barrow Observatory



- Mean seasonal cycle is quite different from the background
- Background very similar to other sites to north and south



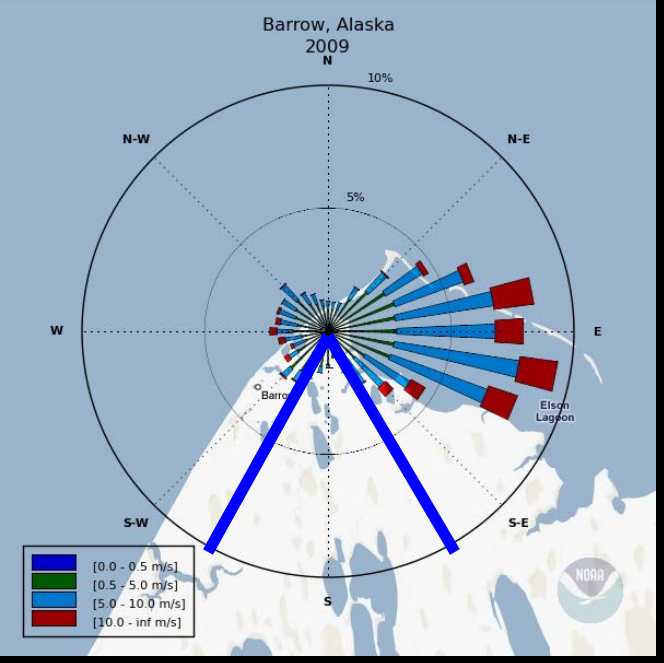
Seasonal cycle from the North Slope



Emissions last from June through December

Soil temperatures may control CH_4 emissions

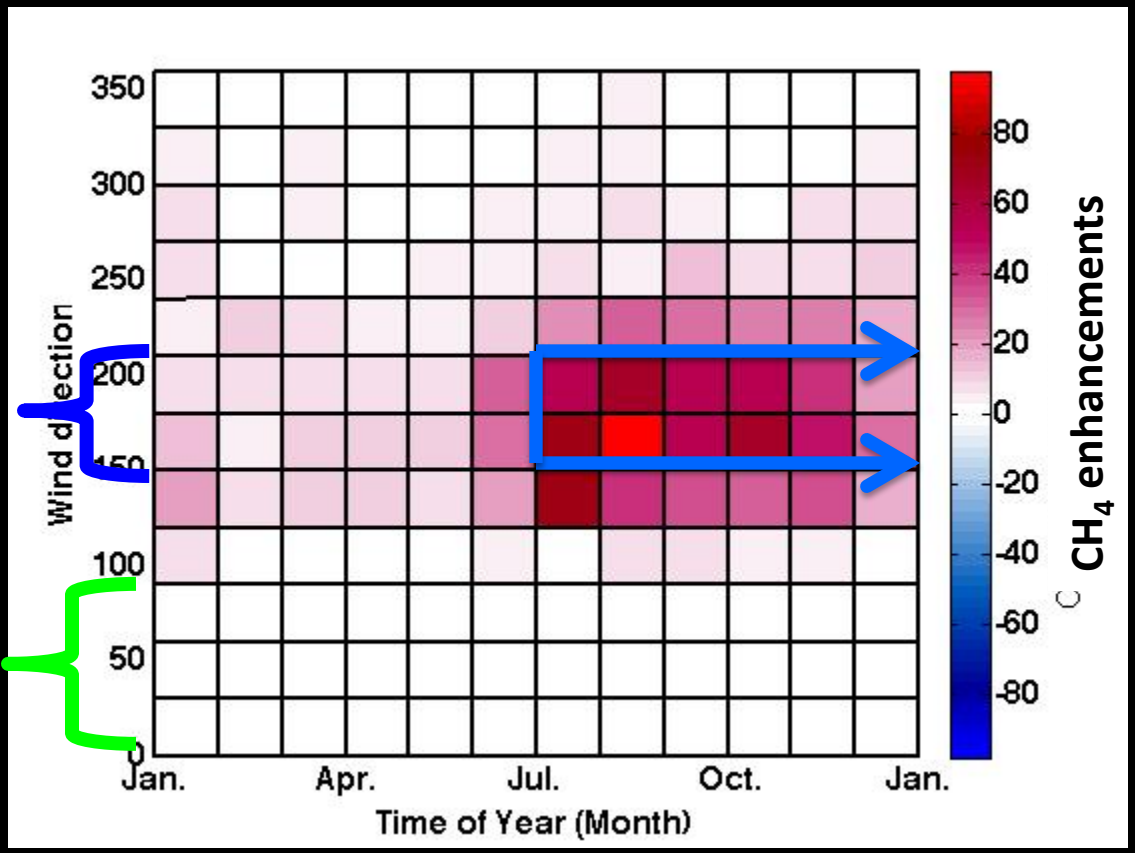
CH_4 at Barrow Observatory



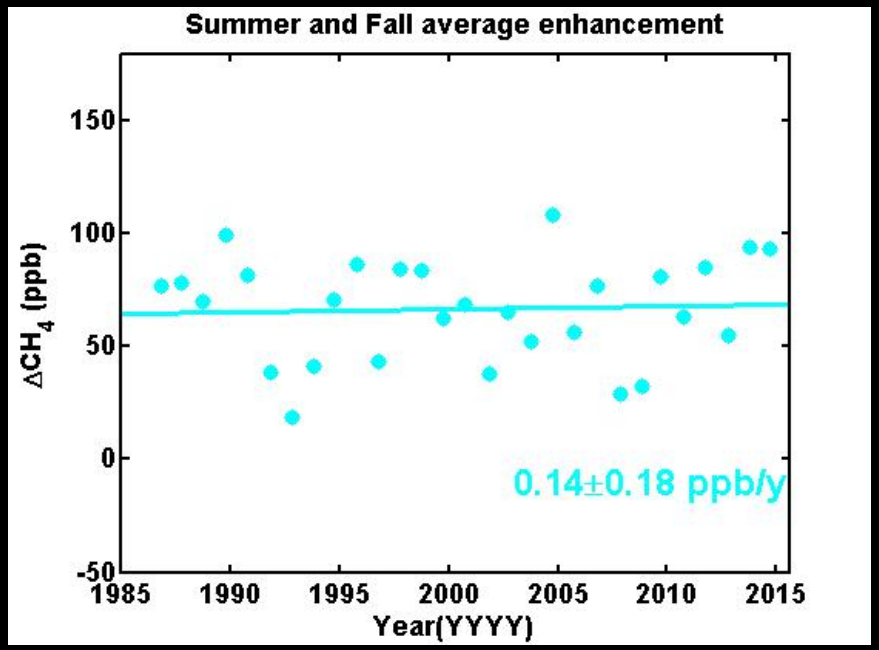
Average enhancements of >70 ppb from southern sector in late summer.

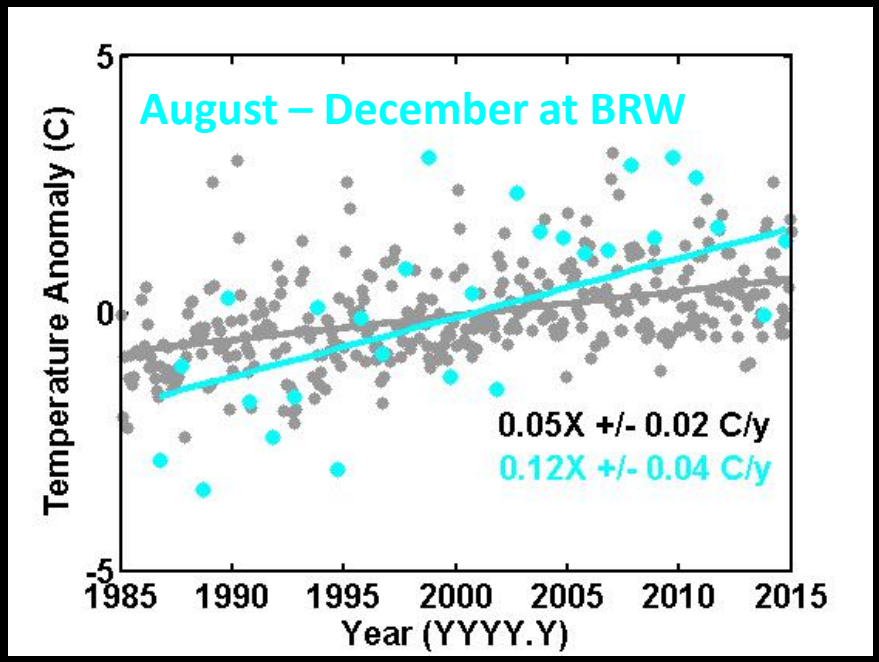
Land sector

Clean air sector



Trends in ΔCH_4 and temperature



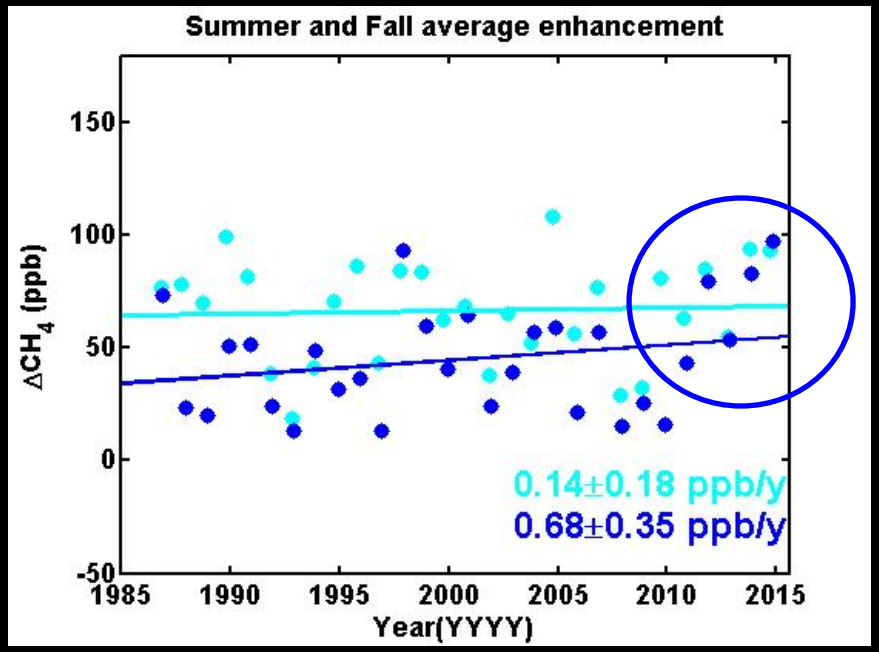


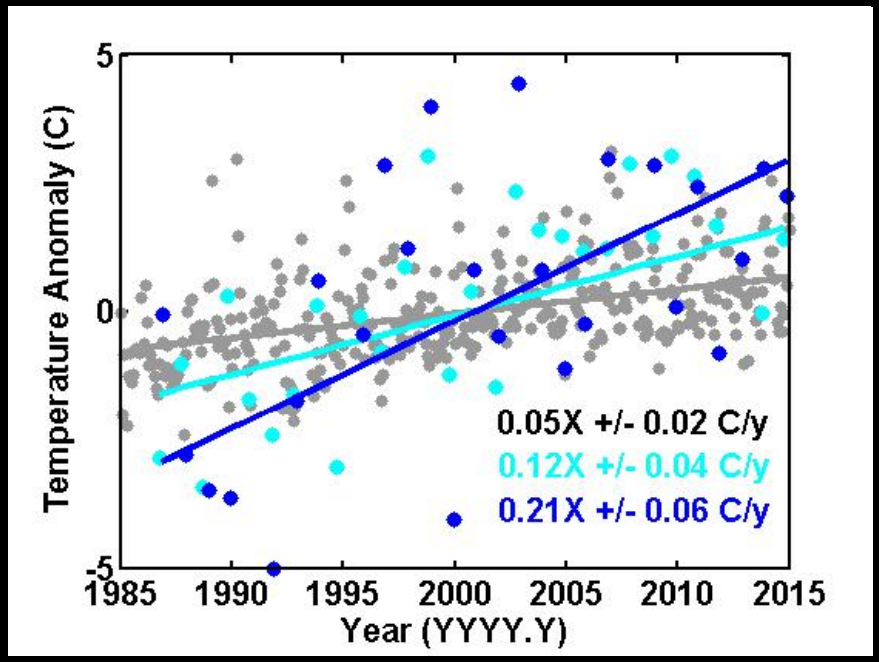
CH_4 enhancements

Temperature

The long term record at Barrow does not suggest that early winter (Aug-Dec) enhancements have changed over the last 29 years

Trends in ΔCH_4 and temperature



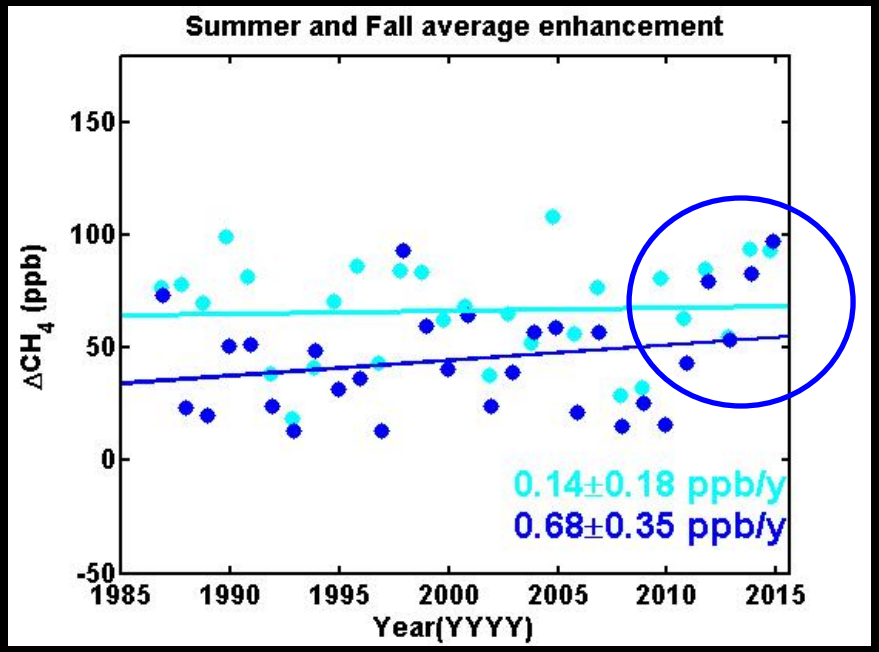


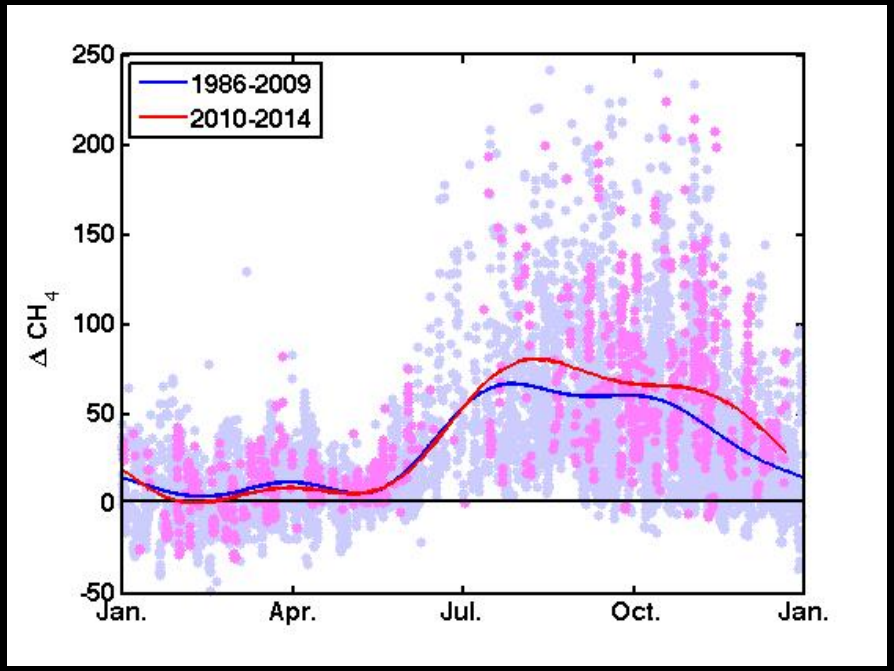
CH_4 enhancements

Temperature

Possible CH_4 enhancement in the last 5 years in November and December

Trends in ΔCH_4 and temperature



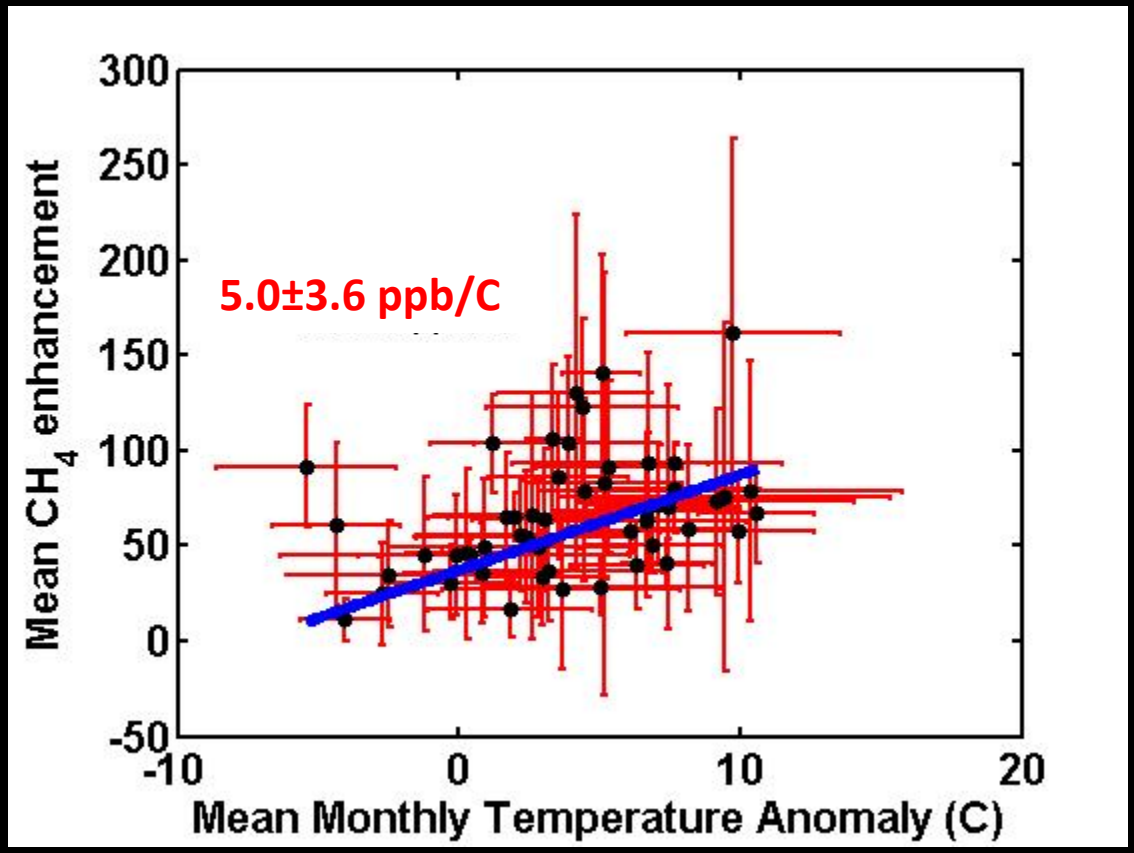


CH_4 enhancements

Possible CH_4 enhancement in the last 5 years in November and December

ΔT v. ΔCH_4

Monthly deviation in temperature verses ΔCH_4



Q_{10}=~2

Short-term trend: Monthly deviation in temperature trend verses enhancements in CH_4 from North Slope. Suggests significant short term response in CH_4

What is the big deal?

Long Term (29 years):

- Increase in T = 3.5 ± 2.3°C
- Increase in 4 ± 6 ppb CH_4

= 1.1 ± 1.8 ppb CH_4/°C

Short Term (~1 month)

= 5.0 ± 3.6 ppb CH_4/°C

What is the big deal?

By 2080 temperatures Arctic early winter may increase by 3-6°C:

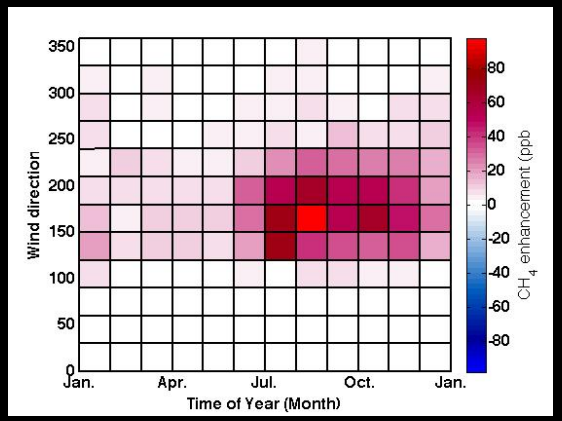
Long-term response → -2–17 ppb CH_4

Short-term response →15–30 ppb CH_4

= - 3 – 45% of average enhancement

If current natural emissions are 19 Tg of CH_4 out of 553 Tg of CH_4/yr:

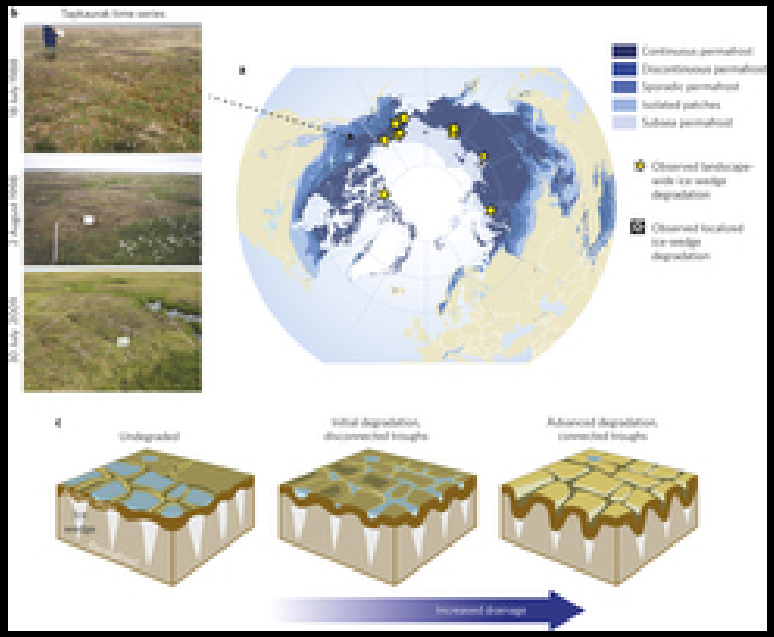
= 1.5% increase in Global emissions



Conclusions

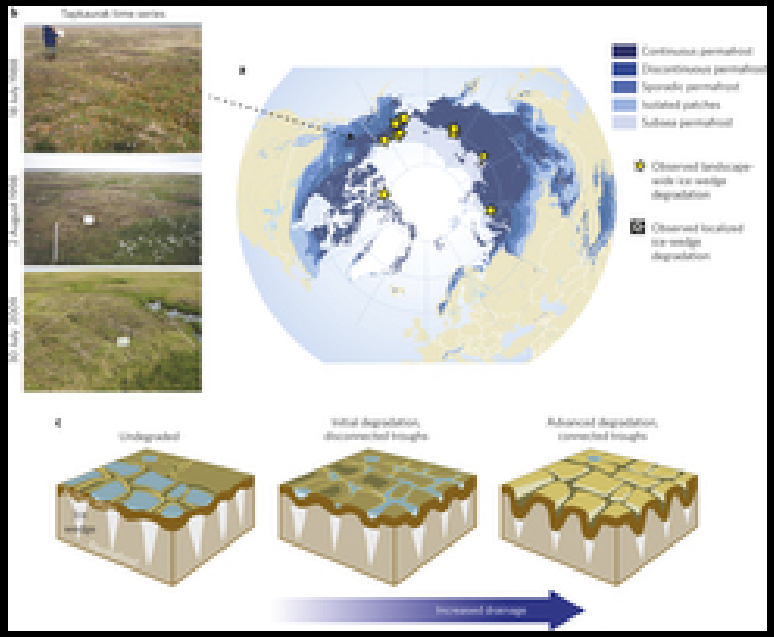
- **No detectable change in CH_4 despite large temperature changes** - A top-down analysis of methane in the Arctic **does not** indicate that there is a significant trend in methane outgassing in the North Slope despite observed increases in temperature.
- **Seasonal cycle –** Starts in June and continues through December despite heavy snow accumulation well before that.
- **Temperature sensitivity –** We only see short-term correlations.
- **Global significance –** Not much (sorry!)

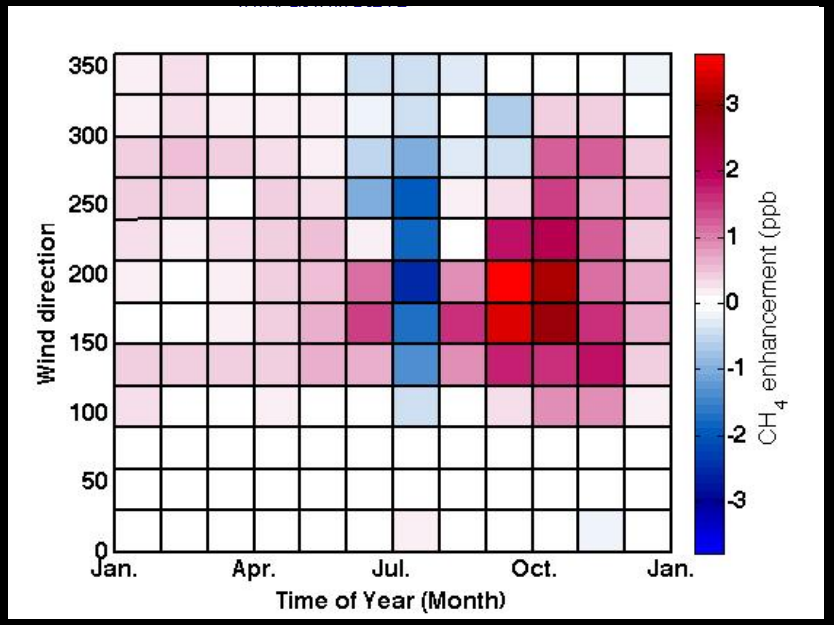
What is happening to the Organic Carbon



"Our hydrological model simulations show that advanced ice-wedge degradation can significantly alter the water balance of lowland tundra by reducing inundation and increasing runoff" (Liljedahl et al. 2016)

What is happening to the Organic Carbon

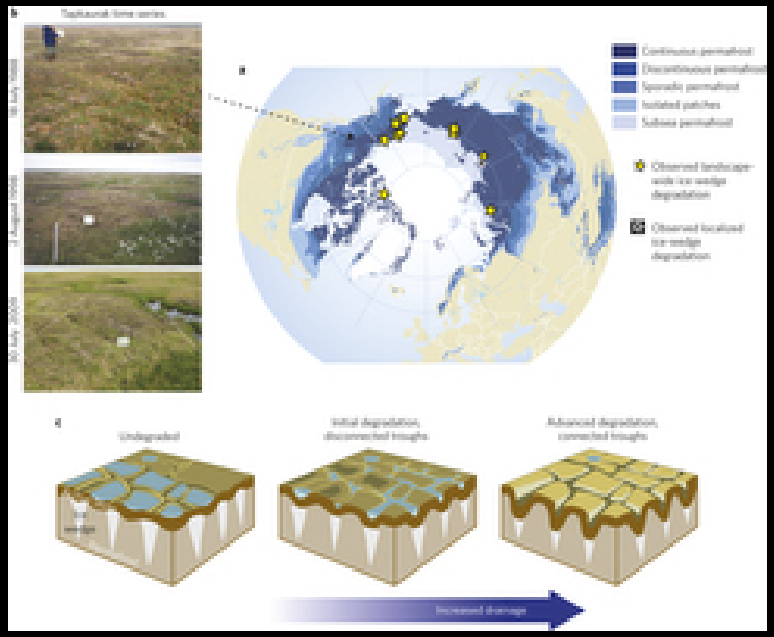


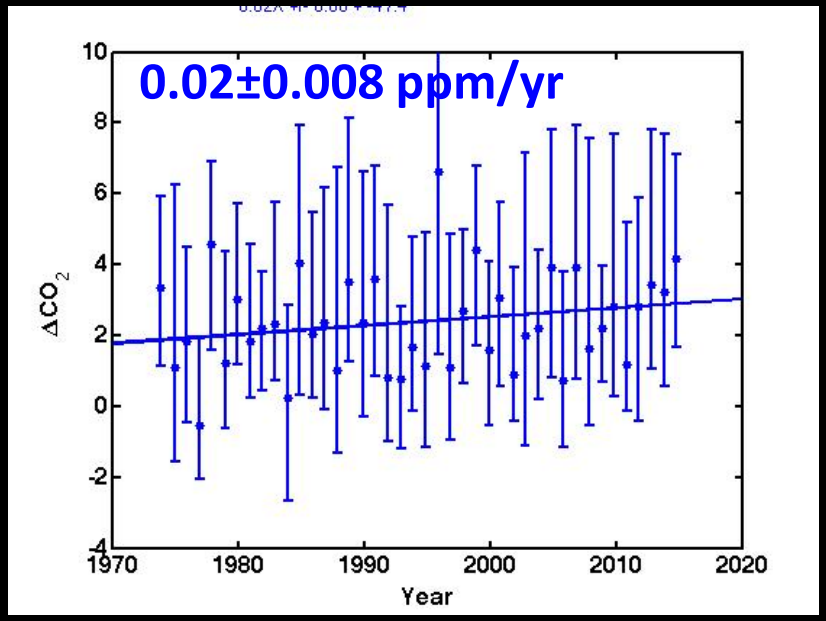


"Our hydrological model simulations show that advanced ice-wedge degradation can significantly alter the water balance of lowland tundra by reducing inundation and increasing runoff" (Liljedahl et al. 2016)

40 year ΔCO_2 record at BRW

What is happening to the Organic Carbon





"Our hydrological model simulations show that advanced ice-wedge degradation can significantly alter the water balance of lowland tundra by reducing inundation and increasing runoff" (Liljedahl et al. 2016)

40 year ΔCO_2 record at BRW

$C_{org} \rightarrow CO_2$

Conclusion

- Despite large changes in climate observed at Barrow and an observed short term response in CH_4 there has been currently no significant increase in CH_4 over the last 29 years at BRW.
- Even if there were a change in CH_4 emissions it would have a small impact on the global budget.