Are high-latitude wetland emissions of CH_4 increasing?

An analysis of seasonal variations in high-latitude NOAA/ESRL CH_4 mole fraction data

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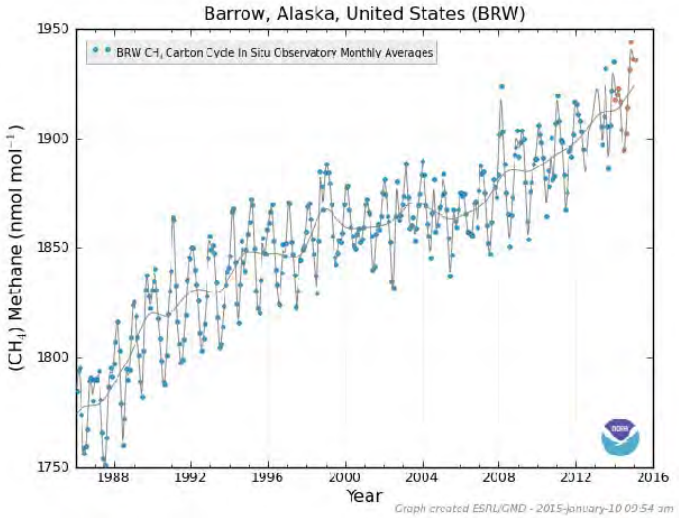
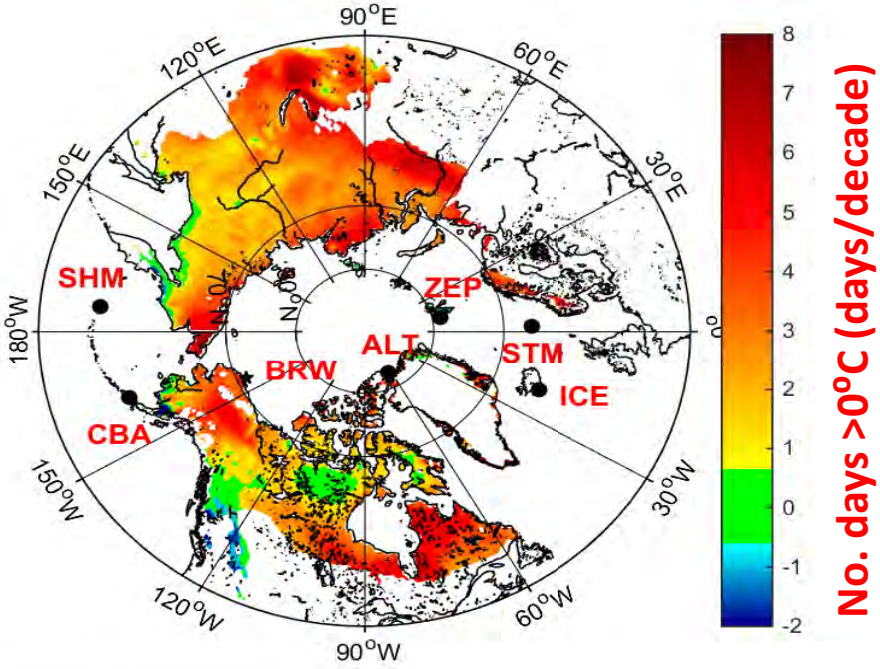
CH_4 data provided by National Oceanic and Atmospheric Administration (Thanks Ed)

CH_4 continues to rise…

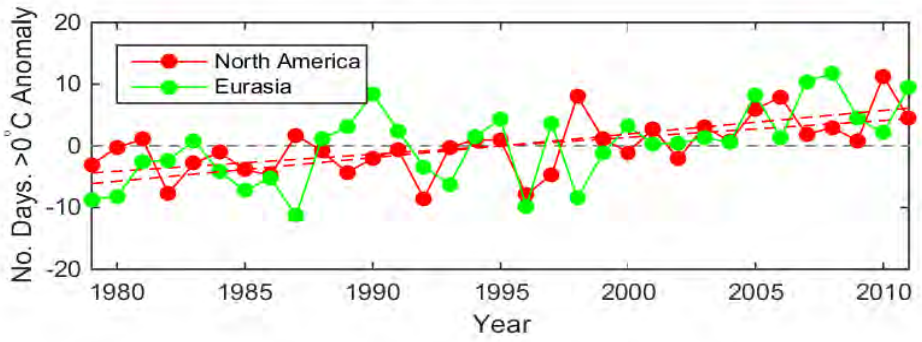


Large uncertainties in global CH_4 budget

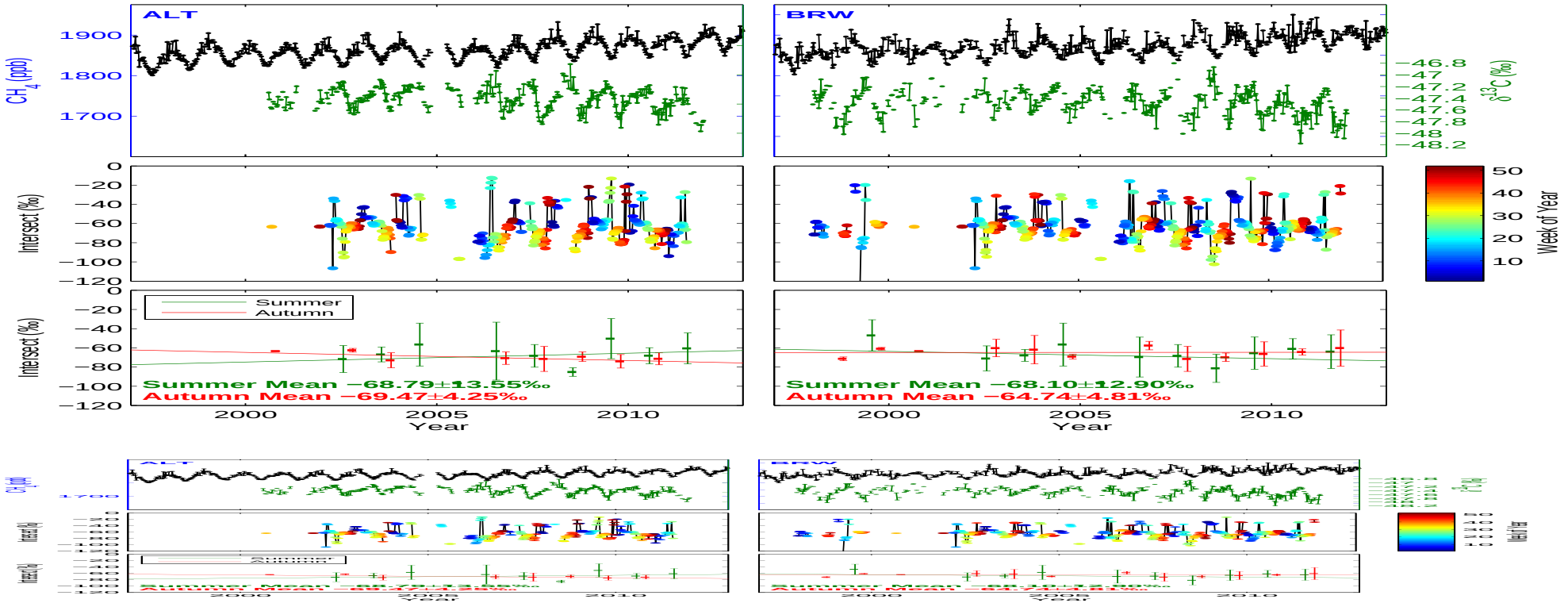


Warming Arctic could be supporting greater methanogenesis and potential increase in emission of CH_4 from wetlands.

Can anything be detected at high-latitude CH_4 flask sites?

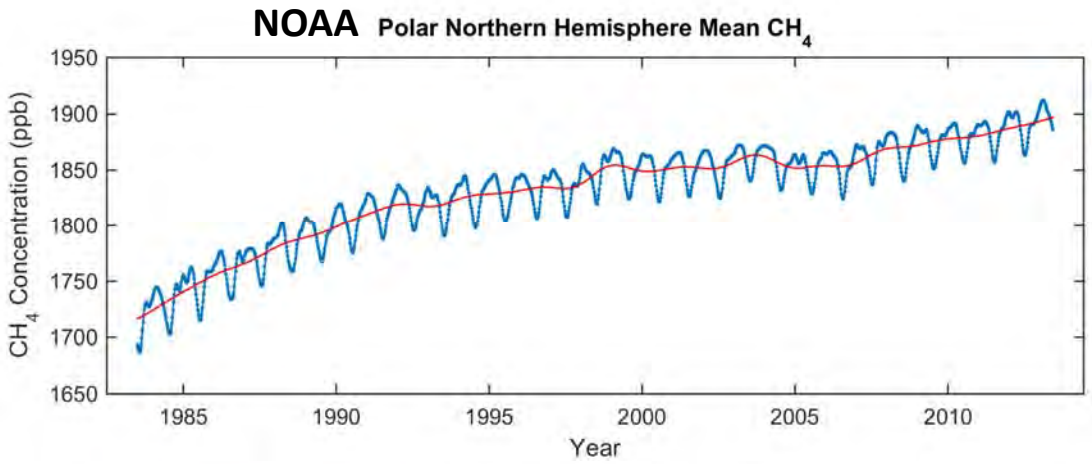


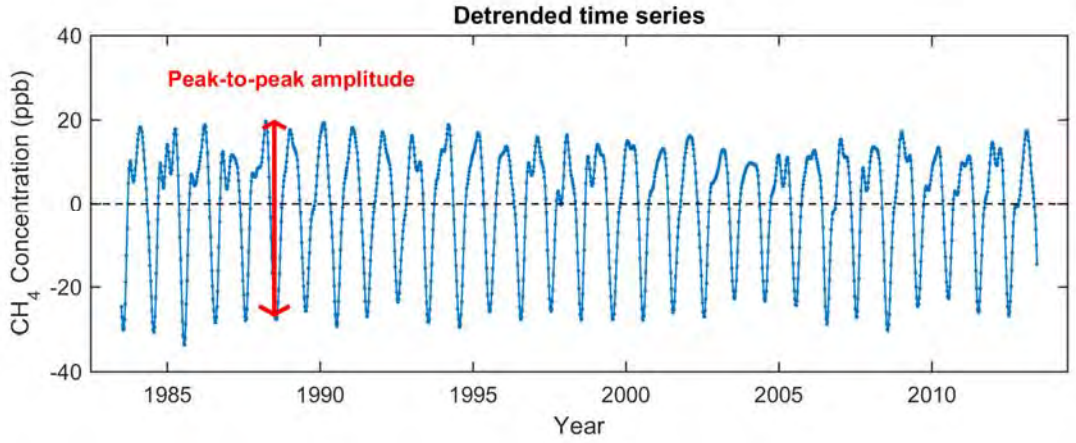
Decreasing values of $\delta^{13}C$ over past decade suggest increasing microbial source … but from tropics, mid-latitudes or high-latitudes?



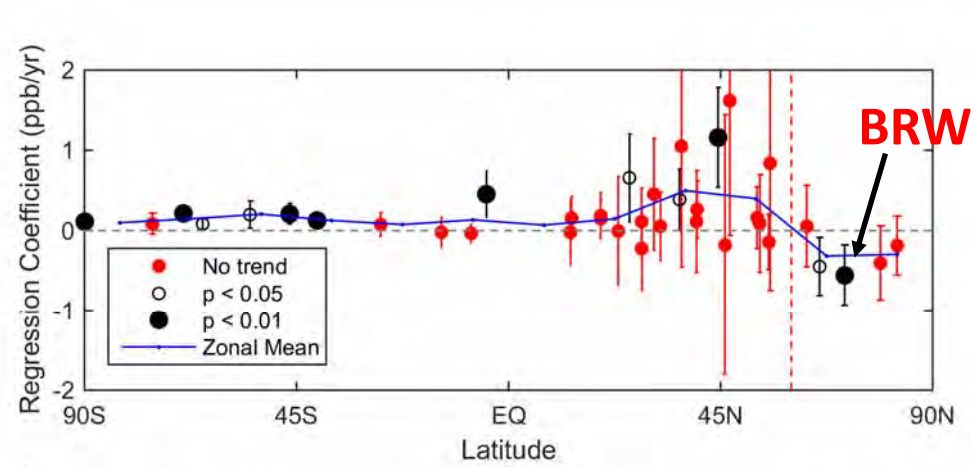
Observed decrease in CH_4 seasonal cycle amplitude at high-latitude sites

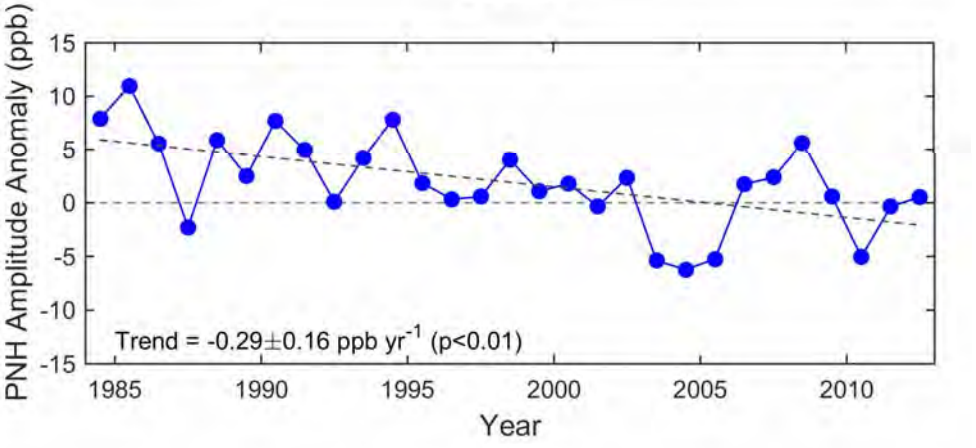
Estimating the seasonal cycle amplitude

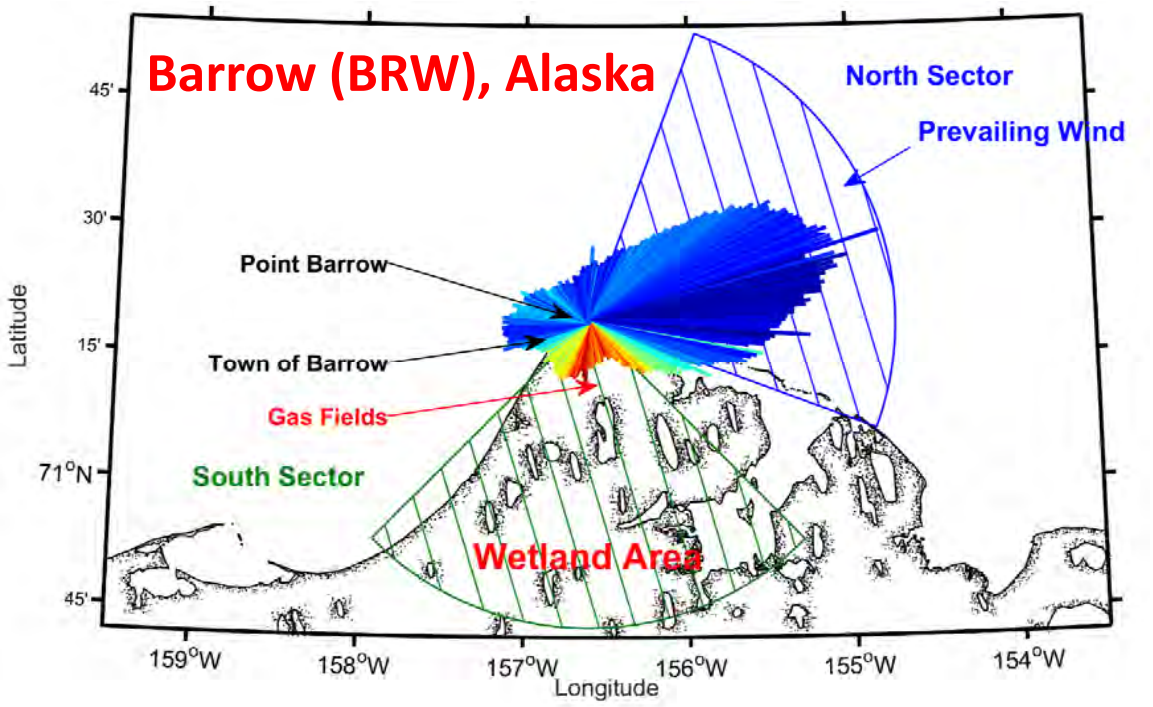


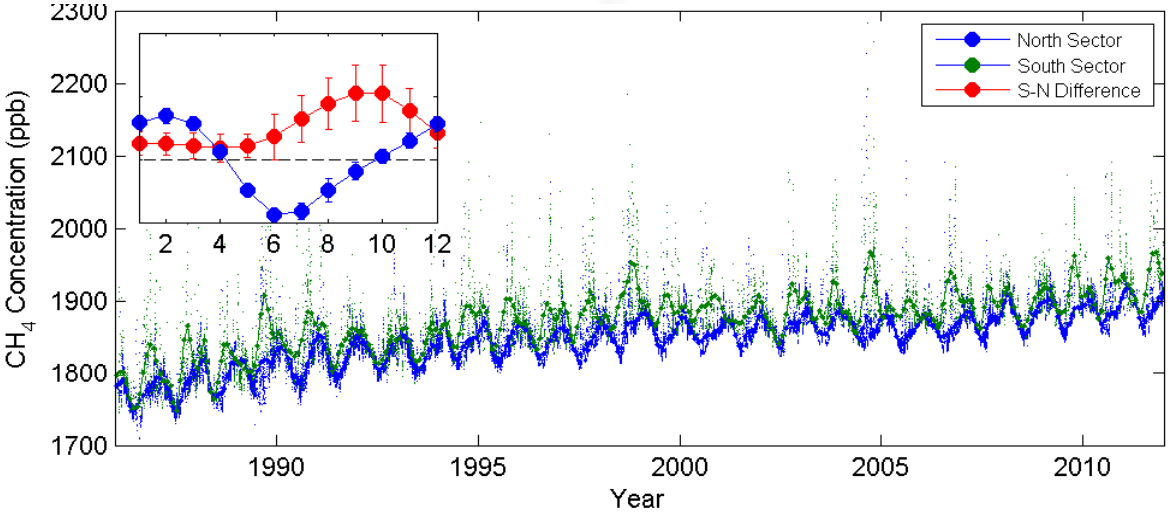


Global trends of seasonal amplitude









High-latitude wetland seasonal cycle is not in phase with ``background'' CH_4 seasonal cycle

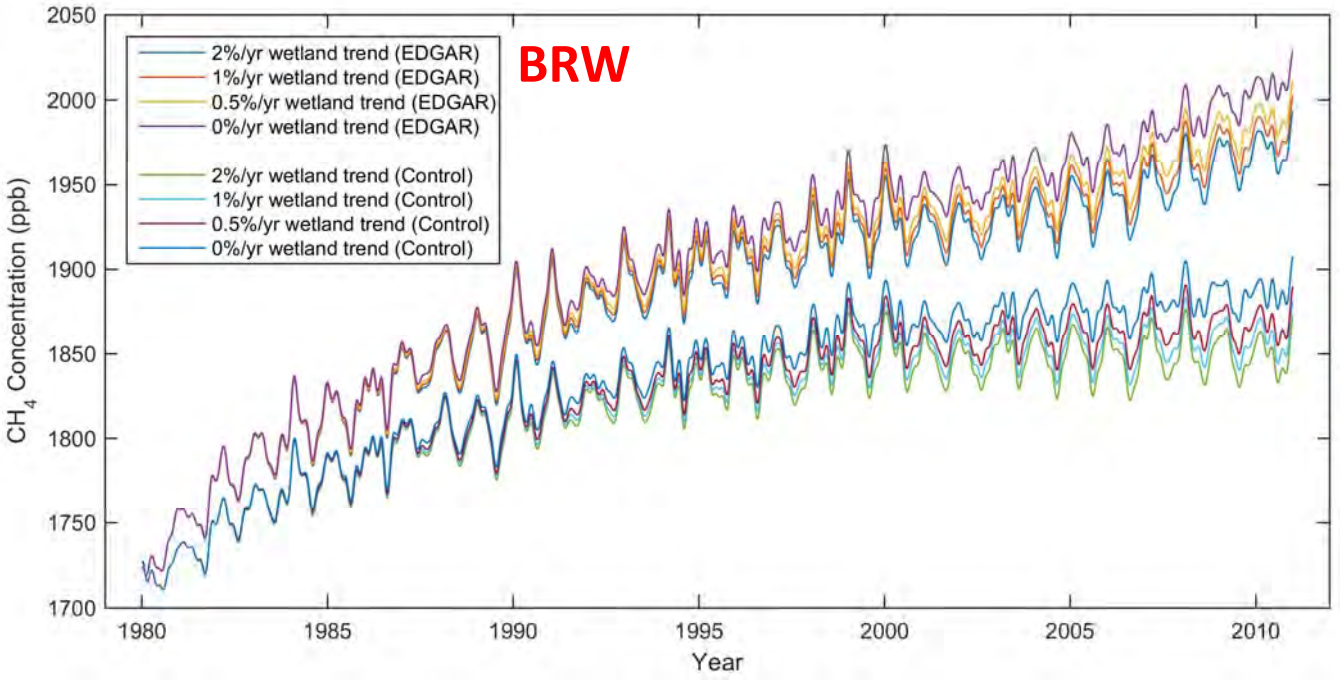
Hypothesis: Increasing wetland emissions are reducing seasonal cycle amplitude by ``filling in'' seasonal cycle minima

Models help to disentangle complex observed variations, linking changes in emissions to changes in the seasonal cycle

TM5 Atmospheric Transport Model

Timespan: 1980 - 2010
Horizontal Resolution: 4° latitude x 6° longitude
Vertical Resolution: 34 hybrid sigma pressure levels
Meteorology: ECMWF

Anthropogenic emissions: EDGAR
High-latitude wetland source prior: 25Tg/yr

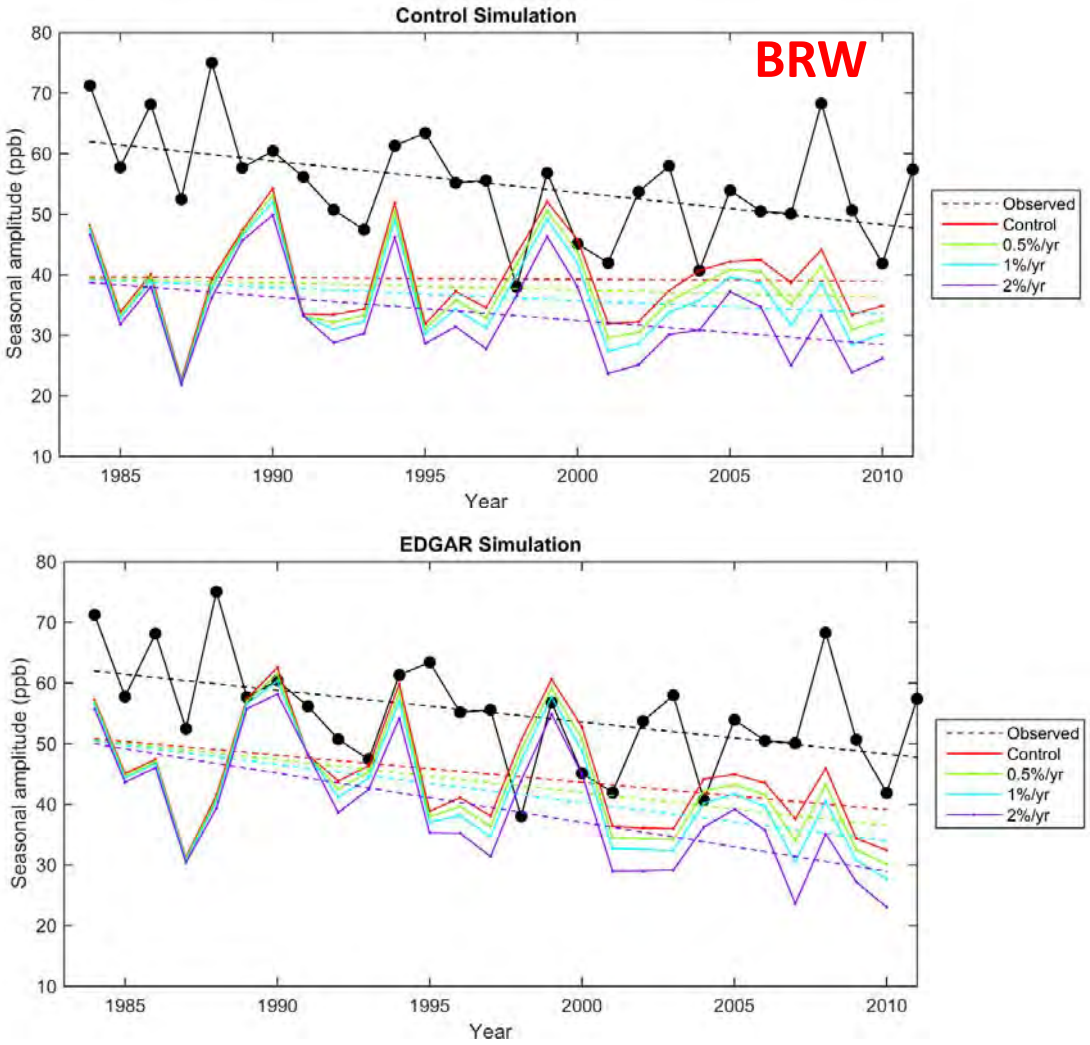


Simulations

Background:
Control simulation (constant emissions)
EDGAR simulation (varying anthropogenic)

High-latitude wetland scenarios:
0.5%/yr, 1%/yr, 2%/yr
+ natural variability

Emissions from anthropogenic sources and wetlands can explain observed trend



Regression Coefficients (ppb/yr)

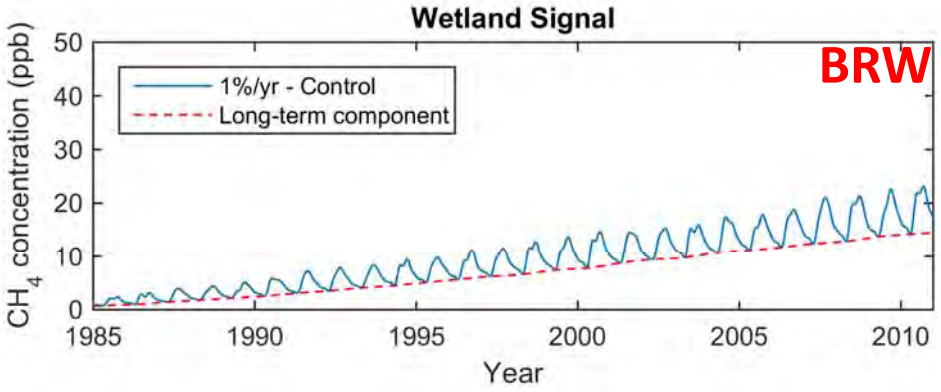
	Control	EDGAR
0.0%/yr	-0.02±0.38	-0.45±0.42*
0.5%/yr	-0.12±0.38	-0.54±0.42*
1.0%/yr	-0.21±0.38	-0.63±0.42**
2.0%/yr	-0.39±0.38*	-0.81±0.42**

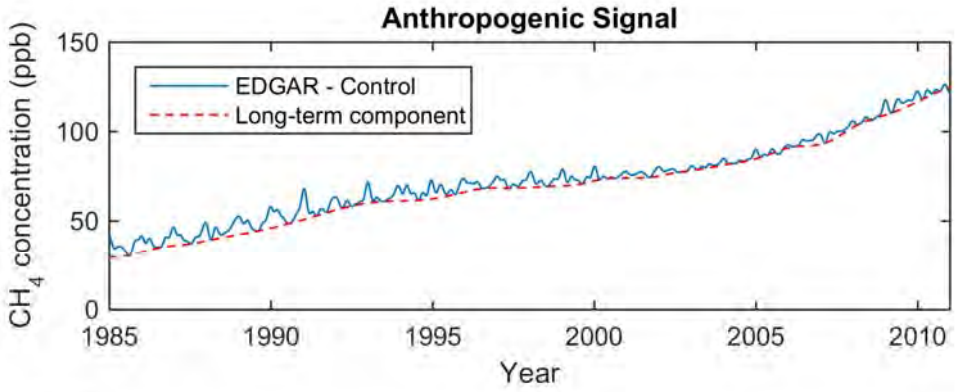
Observed: - 0.58±0.42**

*** P < 0.05, ** P < 0.01**

- Meteorology drives much interannual variability in the seasonal amplitude but not the trend
- Anthropogenic emissions from EDGAR lead to significant decrease in amplitude but not as large as observed
- High-latitude wetland emissions can explain remaining trend

Disentangling Signals





- Seasonal wetland signal peaks towards end of summer/beginning of autumn, coinciding with maxima/ascending edge of CH_4 seasonal cycle
- Increase in seasonal peak leads to reduction in amplitude

- Seasonal anthropogenic signal peaks in December/January, coinciding with maxima of CH_4 seasonal cycle
- Decrease in seasonal peak leads to reduction in amplitude

Summary

- Observed decrease in CH_4 seasonal amplitude at some high northern latitude sites
- Atmospheric transport drives significant interannual variability in the seasonal amplitude but not the trend.
- If we assume that the anthropogenic emissions in the TM5 model experiments are correct, this suggests that up to 75% of the amplitude trend could be in response to changes in anthropogenic emissions.
- An additional change of +0.73%/yr (relative to 25Tg prior) in high-latitude wetland emissions would explain remaining change (25%).