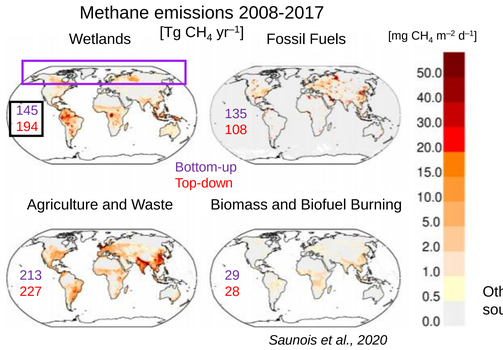
Synthesis of Arctic-Boreal region biogenic methane fluxes, model-data mismatch, and knowledge gaps

***Luke D. Schiferl[1,2] (schiferl@seas.harvard.edu)**, Shannon Reault[3], Hailey Webb[4], Abhishek Chatterjee[5], Róisín Commane[2,6], Mary Farina[7], Elizabeth Hoy[8], Benjamin Poulter[8], Jennifer Watts[4], and Zhen Zhang[9]*

1. Harvard John A. Paulson School of Engineering and Applied Sciences, Cambridge, MA, USA, 2. Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, USA, 3. Clark University, Worcester, MA, USA, 4. Woodwell Climate Research Center, Falmouth, MA, USA, 5. NASA Jet Propulsion Laboratory, Pasadena, CA, USA, 6. Department of Earth and Environmental Sciences, Columbia University, NY, USA. 7. Montana State University, Bozeman, MT, USA, 8. NASA Goddard Space Flight Center, Greenbelt, MD, USA, 9. Earth System Science Interdisciplinary Center, University of Maryland, College Park, MD, USA

Global Methane Budget



Saunois et al., 2020

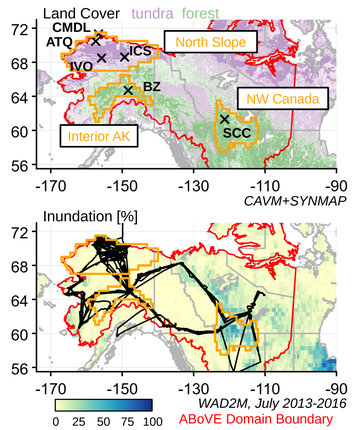
Uncertainty in global methane budget dominated by wetlands and other natural sources

Other natural sources: 222 39

Are we missing natural (or warming-induced) sources in Arctic-boreal regions?

How do we define an ecosystem biogenic methane emitting surface or region?

ABoVE Domain Methane Observations and Simulations



Diverse ecosystem types: tundra, forest, dry, wet

Bottom-up

× eddy covariance flux towers
e.g., Scotty Creek, Bonanza Creek, Ivotuk
global / regional models
e.g., Global Carbon Project (GCP) ensemble, WetCHARTs ensemble, TCF

Top-down

— aircraft concentration measurements
e.g., ABoVE Arctic-CAP, ARM-ACME V
regional optimizations
e.g., CARVE Alaska

Atmospheric Evaluation of Biogenic CO_2 Fluxes

Using atmospheric observations to quantify annual biogenic carbon dioxide fluxes on the Alaska North Slope

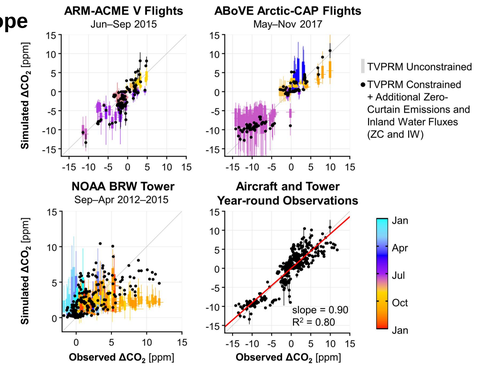
Schiferl et al. (2022) Highlight article in *Biogeosciences*

Atmospheric CO_2 concentration observations help evaluate several biogenic CO_2 flux models – **both growing season net uptake and cold season respiration.**

Additional **zero-curtain CO_2 emissions** not driven by soil temperature and **CO_2 fluxes from inland water** important for reproducing observations on the Alaska North Slope.

Recent quantifications of cold season emissions are **likely overestimated** for this region during Jan–Apr, enough to **change the sign** of the annual net CO_2 budget.

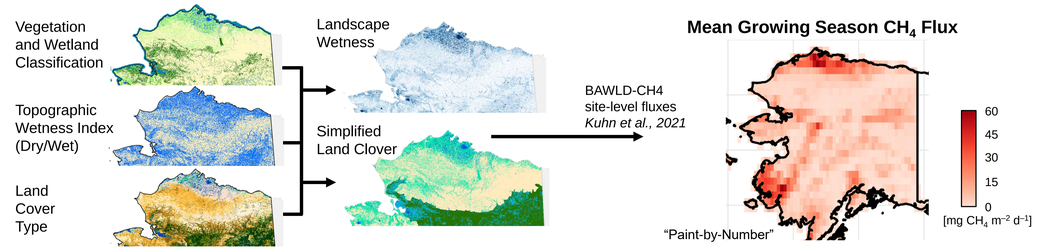
Constrained by the atmospheric observations, the Alaska North Slope net CO_2 flux ranges from –6 to 6 TgC for 2012–2017. **In each year, the sign is determined by the magnitude of the net CO_2 flux in the growing season.**



Explore the biogenic CO_2 flux model comparisons!
atmoscomp.ldeo.columbia.edu/tvprm

ABoVE and ABoVE-affiliated projects:
McKain (TE 2016), Munger (CARBON 2016), Anderson (NSF 2018), Natali (TE 2014), Watts (NIP 2017)

Baseline Methane Flux from Land Cover and Wetness

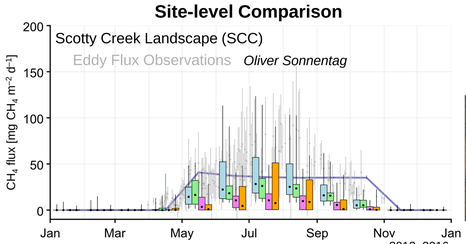


Simple approach reproduces well atmospheric methane observations

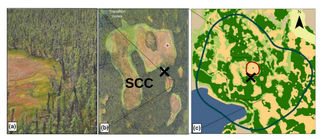
Site-level and Regional Comparisons

Scotty Creek / NW Canada

Site-level Comparison

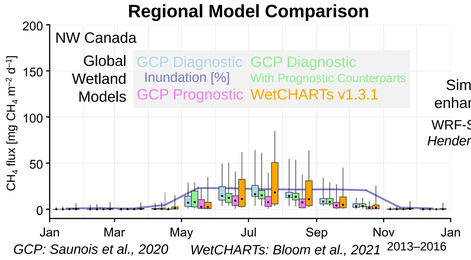


Wetland methane models reproduce observations in boreal wetland areas of NW Canada – magnitude and seasonality



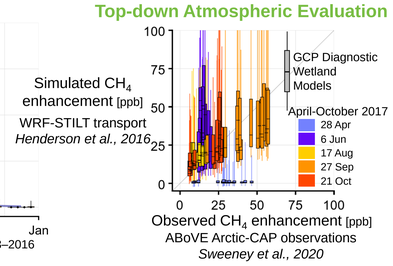
Helbig et al., 2017

Regional Model Comparison



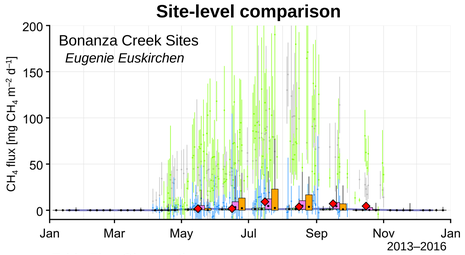
GCP: Saunois et al., 2020 *WetCHARTs: Bloom et al., 2021*

Top-down Atmospheric Evaluation

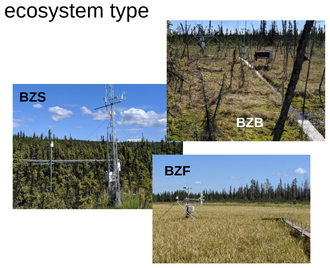


Bonanza Creek / Interior AK

Site-level comparison



Limited methane emissions in Interior AK consistent with observations of dominant ecosystem type

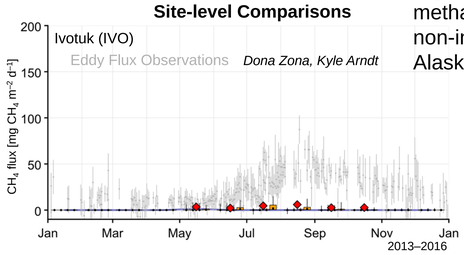


Eddy Flux Observations
Thermokarst Bog (BZB)
Rich Fen (BZF)
Black Spruce (BZS)

CARVE Aircraft Optimized
Miller et al., 2016

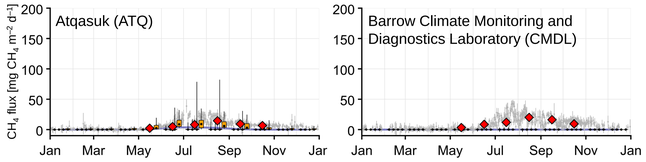
Alaska North Slope

Site-level Comparisons

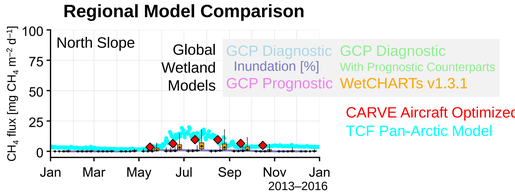


Significant biogenic methane observed from non-inundated areas on Alaska North Slope

Davidson and Zona, 2018

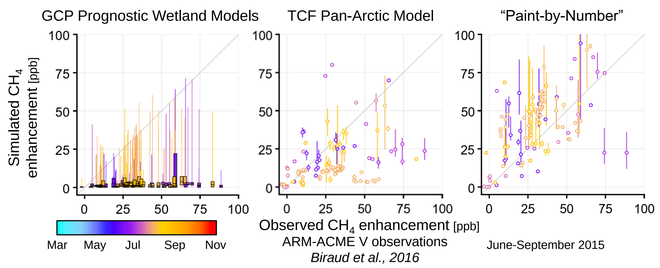


Regional Model Comparison



CARVE Aircraft Optimized
TCF Pan-Arctic Model

Top-down Atmospheric Evaluation



Initial Take-aways

Global wetland models capture magnitude and timing of biogenic methane for inundated and non-inundated boreal forest **– but not Arctic tundra**

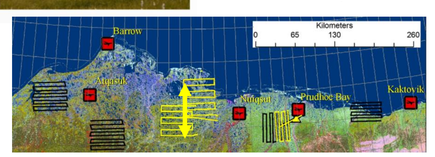
Still investigating reasons:

Inundation not appropriate metric for wet land?
Soil type/subsurface processes/veg type instead?
Wetland methane ≠ ecosystem biogenic methane?
Large contribution from lakes/ponds?

Next Steps

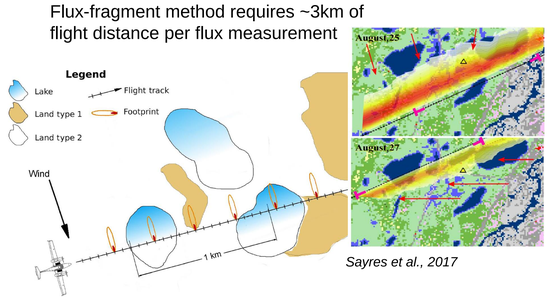
Flux Observations of Carbon from an Airborne Laboratory-2 (FOCAL2) *ABoVE-affiliated Anderson (NSF 2018)*

August-September 2023 Airborne eddy flux measurements of carbon gases and isotopes on Alaska North Slope



Explore CH_4 (and CO_2) fluxes along wetness gradients

Flux-fragment method requires ~3km of flight distance per flux measurement



Sayres et al., 2017

This work is done as part of an ABoVE Carbon Dynamics Working Group synthesis project. Thank you to observational data and model providers cited throughout the poster for your essential contributions.