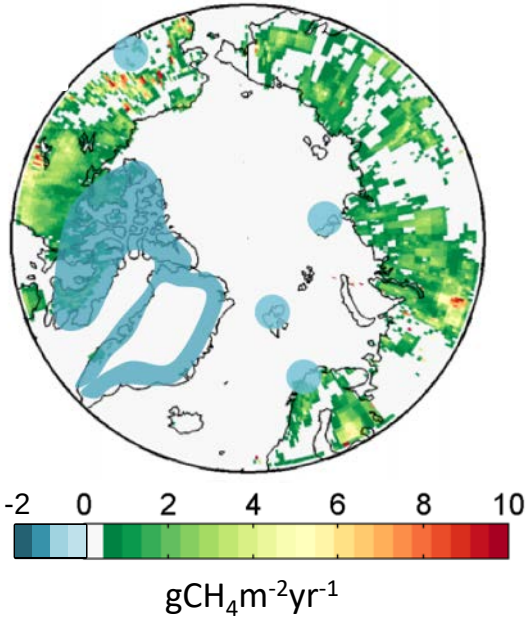
High Affinity Methanotrophs Are an Important Overlooked Methane Sink in the Arctic and Global Methane Budgets

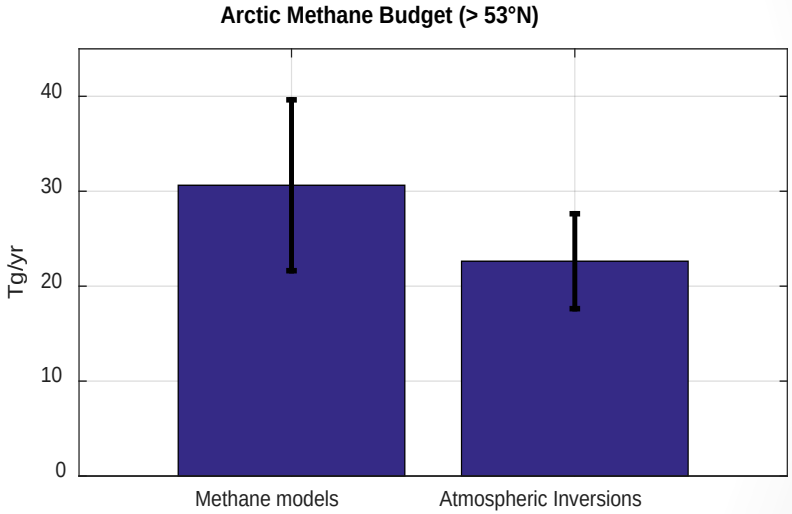
Youmi Oh, Qianlai Zhuang, Licheng Liu, Lisa R. Welp Maggie C.Y. Lau, Tulli C. Onstott, David Medvigy, Gustaf Hugelius, Ludovica D'imperio, Bo Elberling, Stefan Schwietzke, Xin Lan, Sourish Basu, Lori Bruhwiler, and Edward Dlugokencky

NOAA ESRL Global Monitoring Annual Conference 2019

Uncertainties in natural arctic methane budget

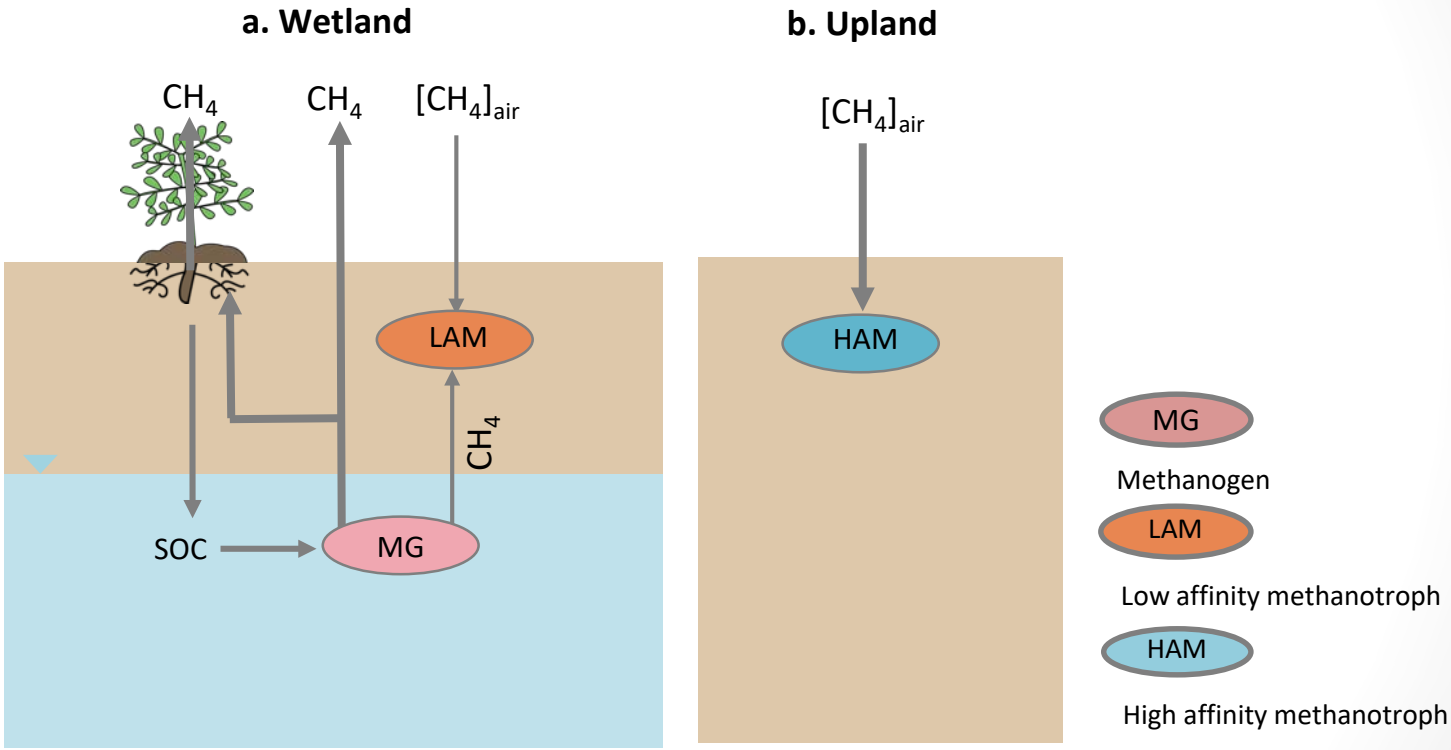
Net Methane Emissions
Simulated by CLM 4.5





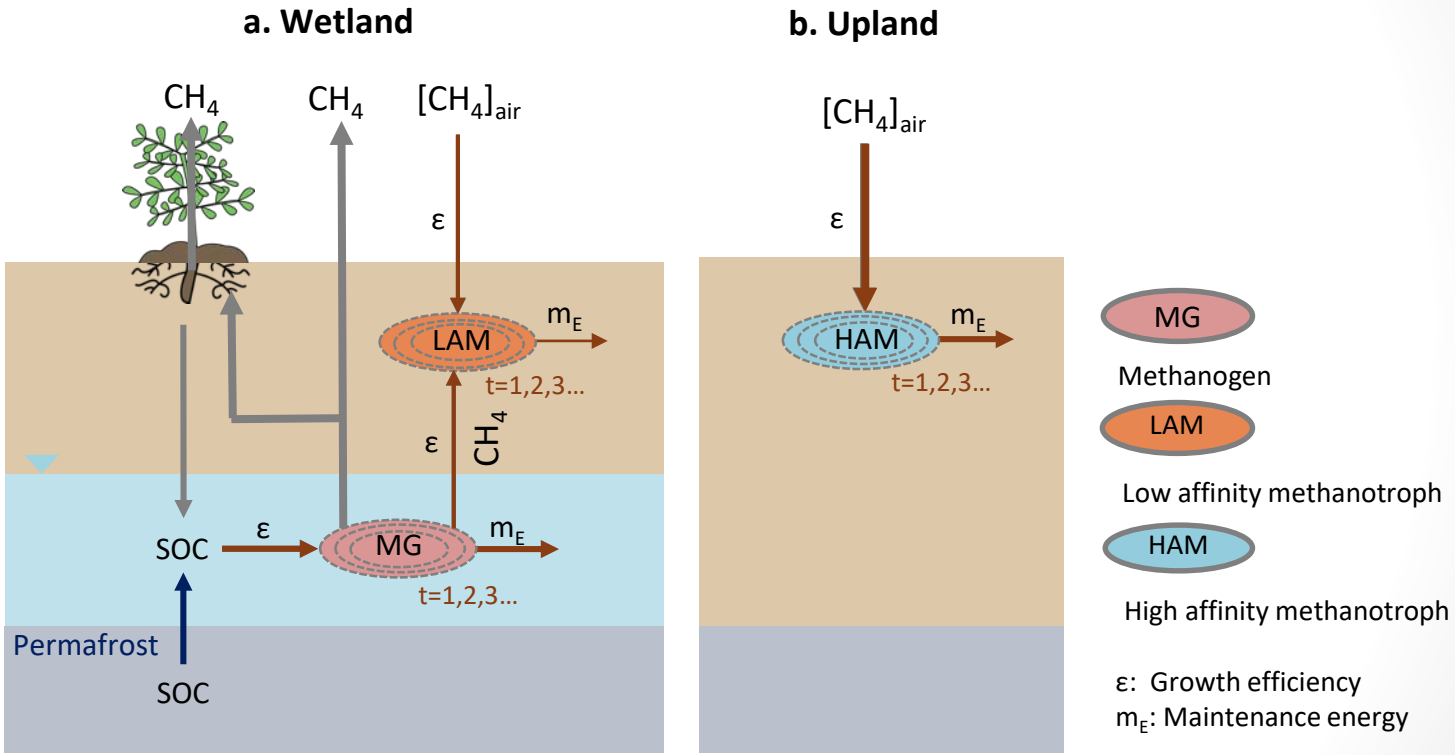
Tarnocai et al. 2009; McGuire et al., 2012; Hinzman et al., 2013; Bruhwiler et al., 2014; Lau et al., 2015; Tan et al., 2015; Saunois et al. 2016

Biogeographic differences in methanotrophs



Le Mer and Roger, 2001; Christiansen et al., 2015

I added microbial and permafrost dynamics into TEM



Zhuang et al., 2004; Zhuang et al., 2006; Zhuang et al., 2013; Oh et al., 2016

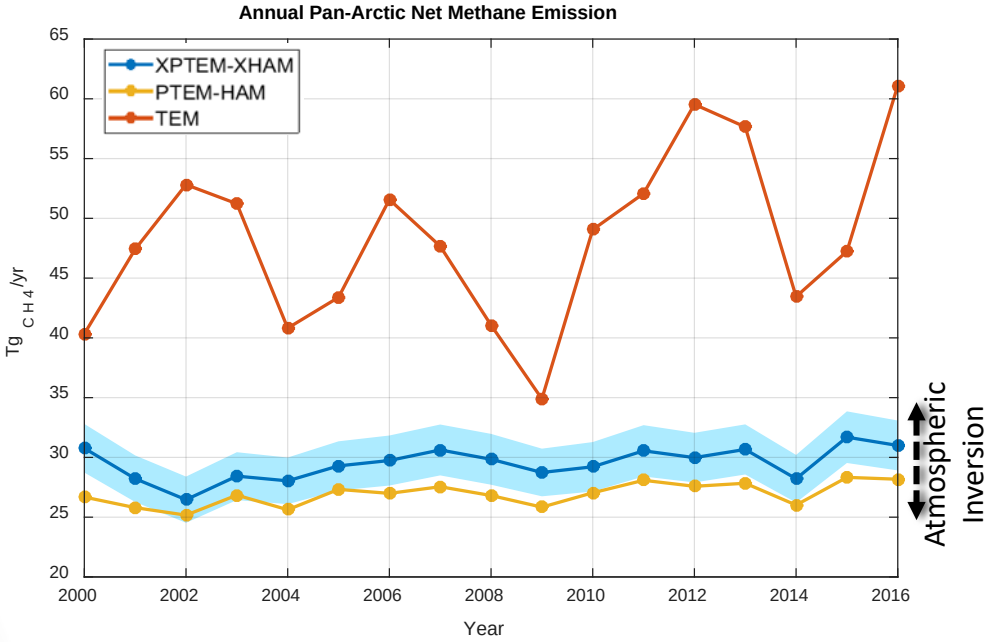
Three model setups for factorial analysis

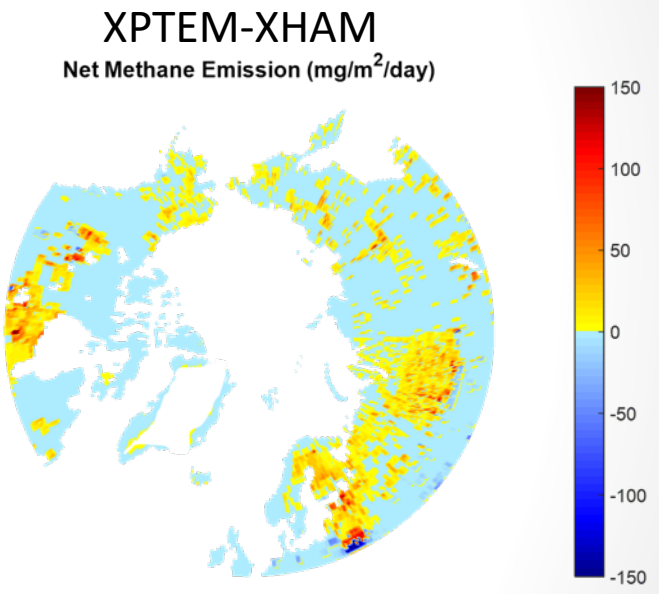
- Simulation was conducted at a spatial resolution of 0.5°×0.5° from north of 50°N for contemporary period (2000-2016) and future projection (2016-2100)

Model Setup	XPTEM-XHAM	PTEM-HAM	TEM
Permafrost Dynamics	ON	ON	OFF
High Affinity Methanotrophs	ON	ON	OFF
Microbial Dynamics	ON	OFF	OFF

Zhuang et al., 2004; Zhuang et al., 2006; Zhuang et al., 2013; Oh et al., 2016

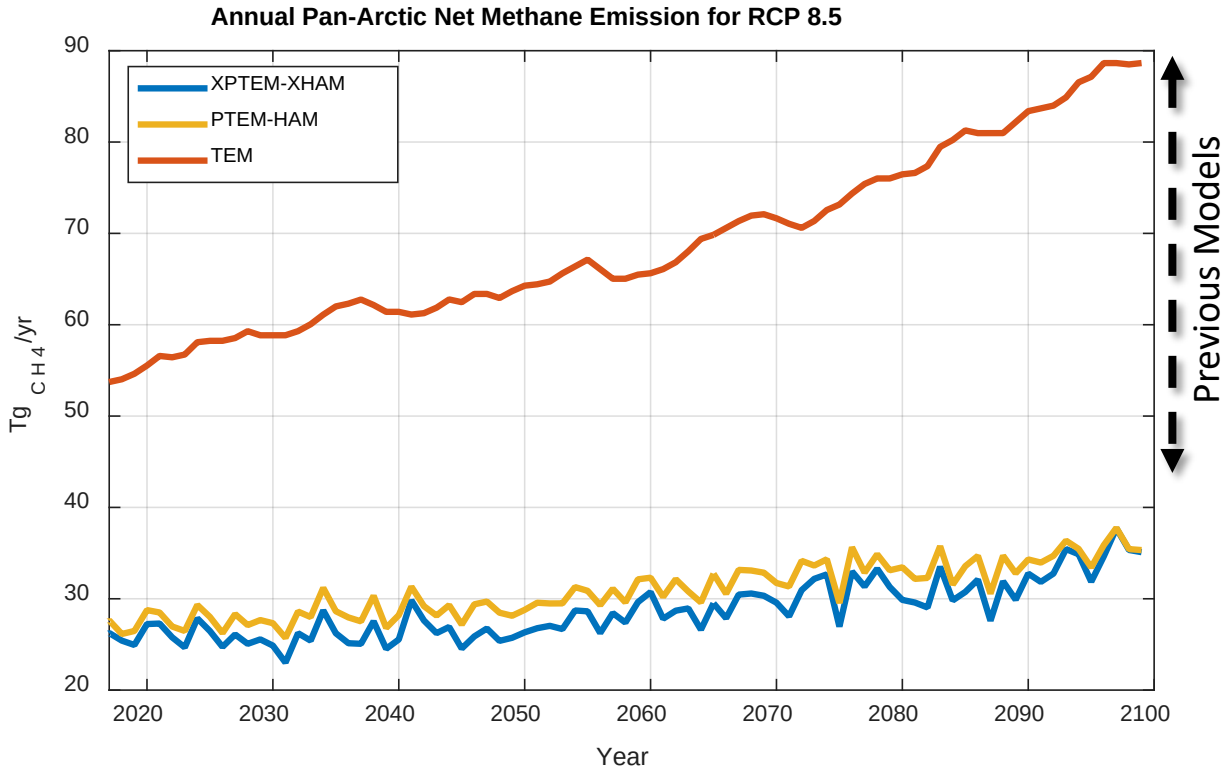
New models show lower CH_4 emissions in 2000-2016





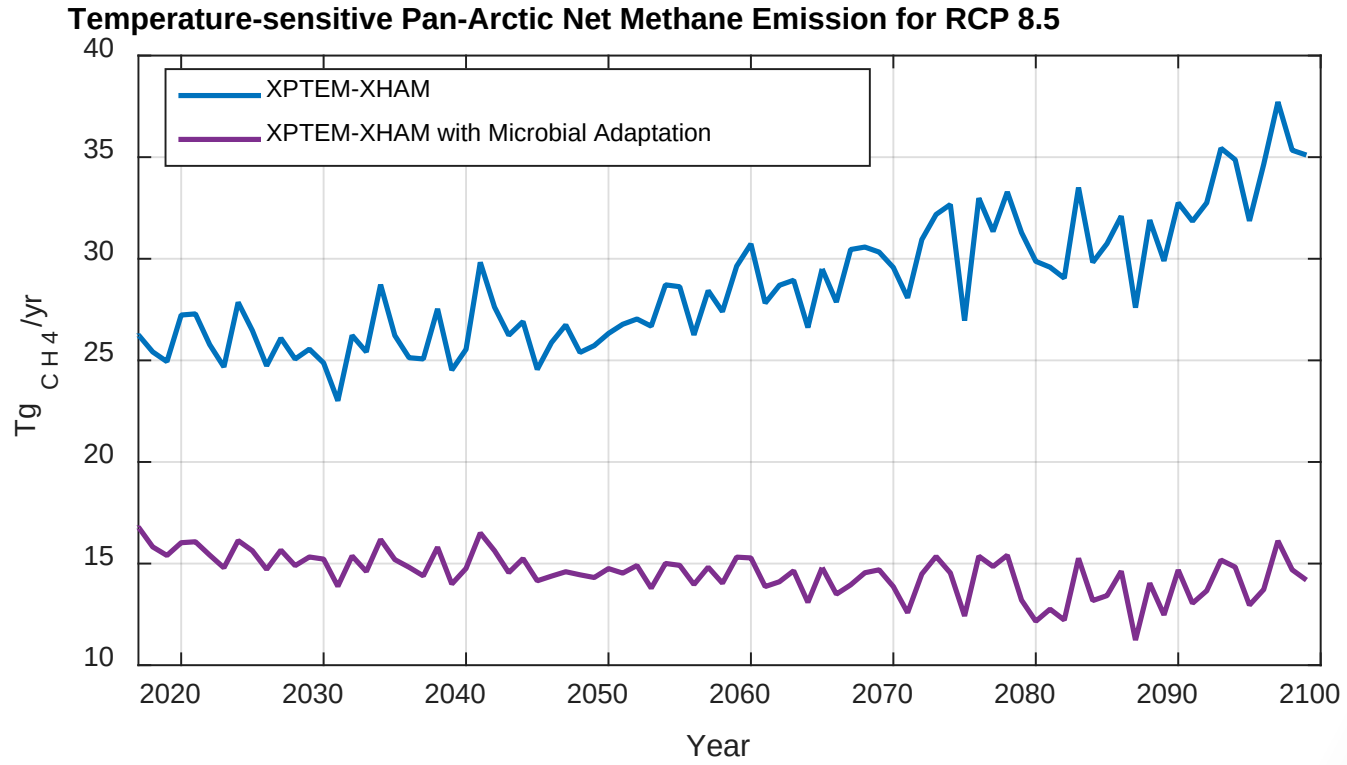
Bruhwiler et al., 2014;Lau et al., 2015; Tan et al., 2015; Saunois et al. 2016

New models project smaller future CH_4 emissions



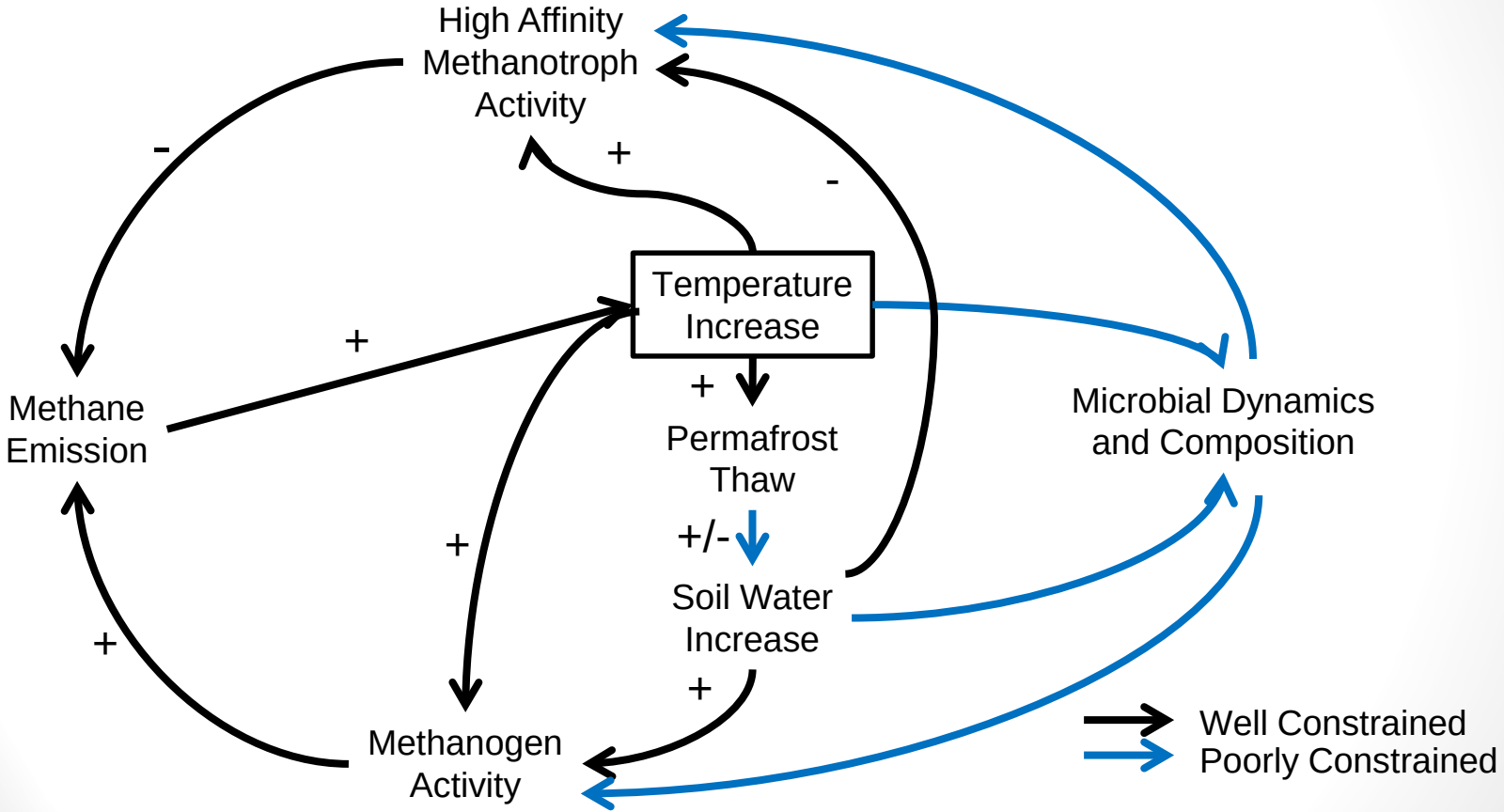
Schaefer et al., 2011; Koven et al., 2011; Schuur et al., 2013; Lawrence et al., 2015

HAM shows a better adaption strategy in the future



Von Stockar and Liu, 1999; Wieder et al., 2013; Trimmer et al., 2015

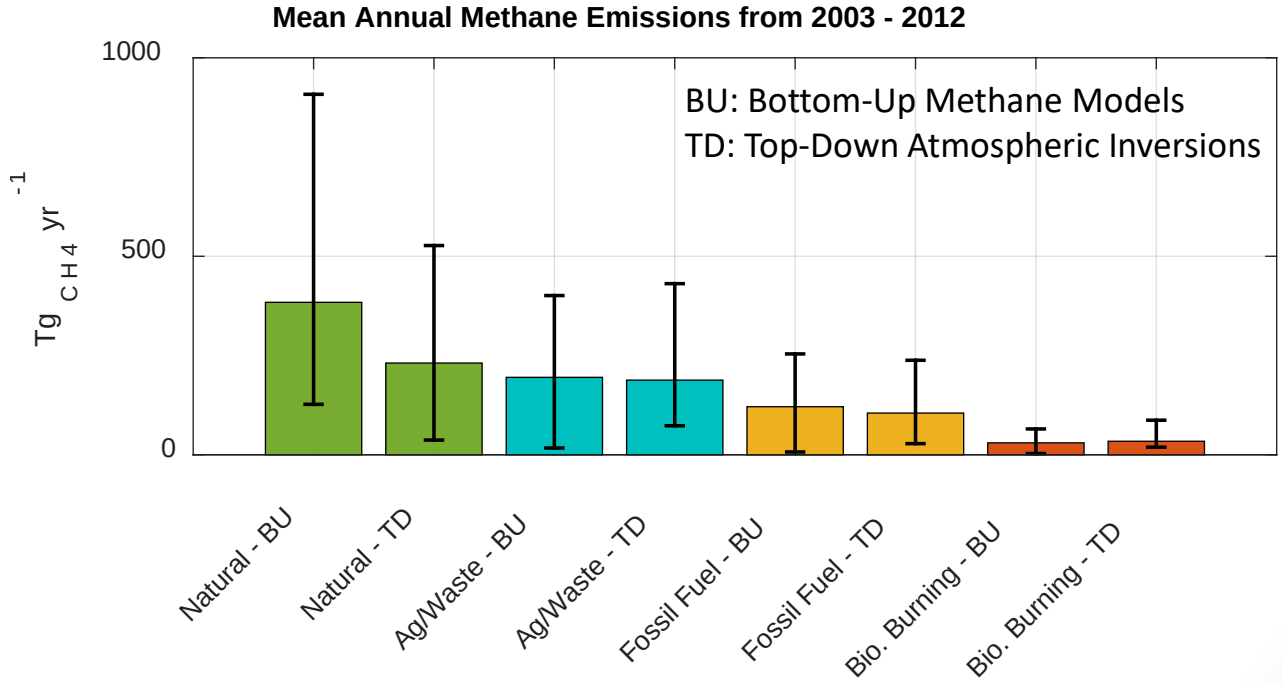
Implication on arctic methane feedbacks



Oh et al., 2016

Models overestimated global natural methane emissions

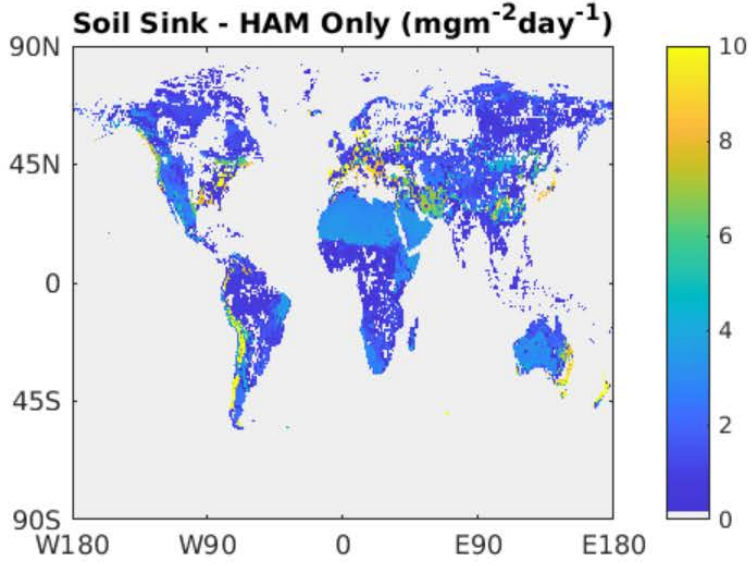
- The current estimation of global methane soil sink is 30 $TgCH_4yr^{-1}$, but with a huge uncertainty (7 to >100 $TgCH_4yr^{-1}$)



Smith et al., 2000; Curry et al., 2007; Dutaur and Verchot, 2007; Saunois et al. 2016

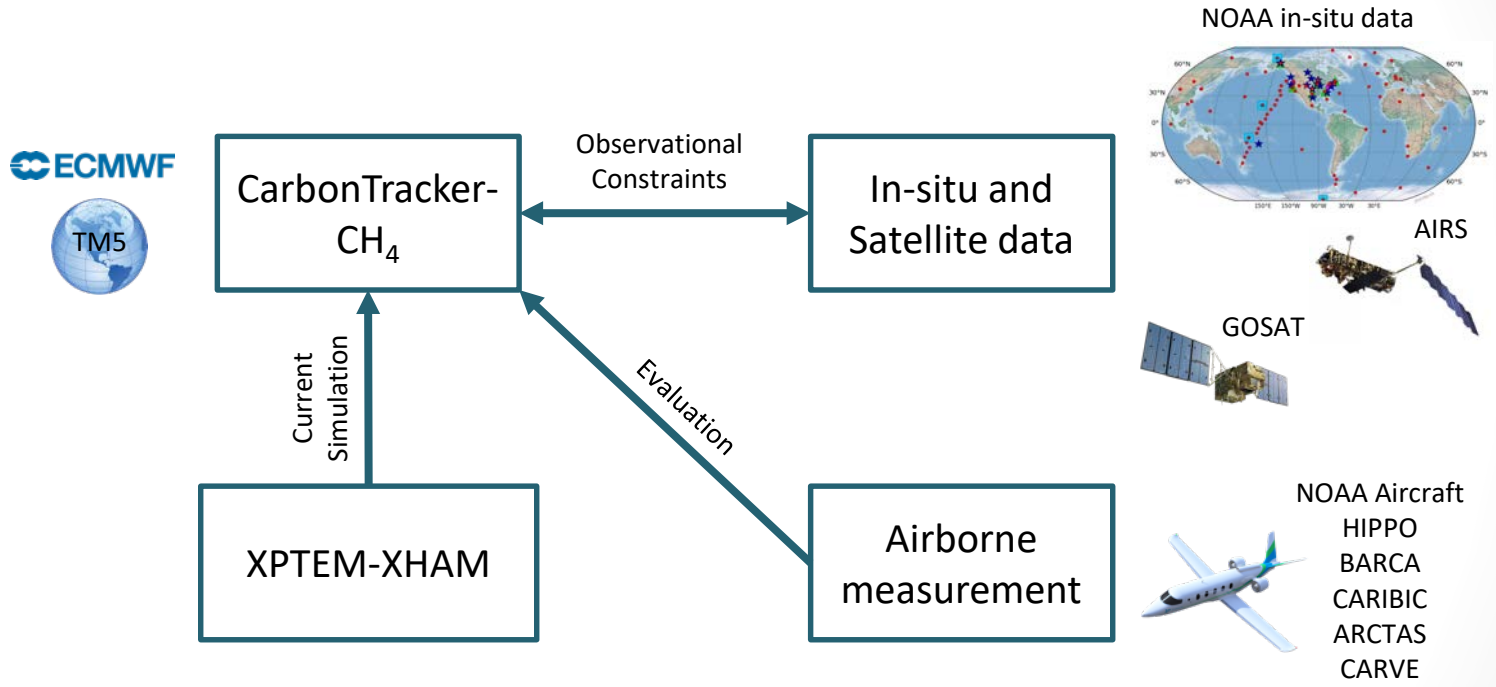
The Global methane soil sink can be up to 3 times larger

Criteria 1 (Tg_{CH4} yr^{-1}) – max. SOC threshold	HAM only
	90
Criteria 2 (Tg_{CH4} yr^{-1}) – max. pH threshold	**HAM only**
	90



Zhuang et al., 2004; Zhuang et al., 2006; Nachtergaele, Freddy, et al. 2010

Inversion simulation using CarbonTracker-CH_4



Peters et al., 2005; Bruhwiler et al., 2011; Bruhwiler et al., 2014

Take Home Message

- We simulated less current and future net methane emissions in the Arctic by considering microbial dynamics of HAM and MG and permafrost dynamics
- The preliminary results show that the global methane soil sink can be up to 3 times larger than the current estimation

- Limitation and future research
  - Validation of the model and hypothesis using atmospheric inversions
  - Validation of the model for sites with a broader range of pH, SOC, and vegetation types using both high and low affinity methanotrophs using meta-data

Acknowledgement

NASA Earth and Space Science Fellowship