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

Y. Oh[1], Q. Zhuang[1], L. Liu[1], L.R. Welp[1], M. Lau[2], T.C. Onstott[2], D. Medvigy[3], G. Hugelius[4], L. D'imperio[5], B. Elberlinig[5], S. Schwietzke[6,7], X. Lan[6,7], S. Basu[6,7], L. Bruhwiler[7], and E. Dlugokencky[7]

[1]Purdue University, West Lafayette, IN 47907; 765-418-3537, E-mail: oh145@purdue.edu
[2]Princeton University, Princeton, NJ 08540
[3]Notre Dame University, Notre Dame, IN 46556
[4]Stockholm University, Stockholm, Sweden
[5]University of Copenhagen, Copenhagen, Denmark
[6]Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, CO 80309
[7]NOAA Earth System Research Laboratory, Global Monitoring Division (GMD), Boulder, CO 80305

Methane oxidation by microbes in soils is the second largest sink in the global methane budget, but its importance has been widely underestimated. Especially in the Arctic, recent field studies have documented a strong and consistent methane sink in mineral soils, thought to be due to High Affinity Methanotroph (HAM) activity. To represent the distinctive physiology of HAM in the Arctic, we simulated regional methane productions and consumptions by implementing explicit microbial dynamics of HAM and permafrost dynamics into a biogeochemistry model. The simulation of a contemporary period showed that our model estimates smaller net annual methane emissions (23 Tg CH_4 yr^{-1}) when compared with a default model without HAM (48 Tg CH_4 yr^{-1}) (Fig. 1). This reduces the gap in estimates of Arctic CH_4 emissions between biogeochemical models and atmospheric inversions. Moreover, without HAM, the model simulated large net emissions (85 Tg CH_4 yr^{-1}) from the Arctic by 2100 under the RCP 8.5 scenario, but with HAM, 30–40 Tg CH_4 yr^{-1} (Fig. 2). Lastly, our model with temperature-sensitive microbial dynamics showed that net Arctic CH_4 emissions could potentially decrease in the future as HAM adapted better in a warmer Arctic than methanogens. Our results emphasize the importance of microbial dynamics to accurately predict the future pan-Arctic methane budget.

Extending our research focus from the Arctic to a global scale, we hypothesize that the additional global methane soil sink by HAM will improve estimates of global methane emissions in process models. Preliminary results show that the global methane soil sink can be up to 90 Tg CH_4 yr^{-1}, when assuming HAM to be dominant in all uplands, which is ~60 Tg CH_4 yr^{-1} larger than previous estimates. We conducted sensitivity tests to change the HAM-dominant regions based on different soil properties and found that the global methane soil sink could be in the range of 35 to 90 Tg CH_4 yr^{-1}. We are running forward and inversion simulations of the global methane budget that consider different soil sink estimates and are constrained by observations from NOAA flask-air measurements and NASA satellite and field campaigns.

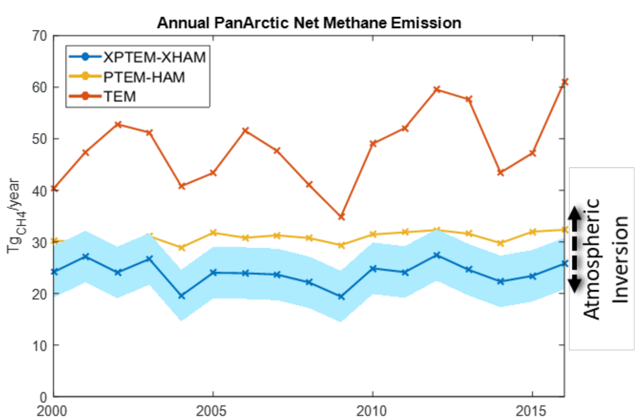

Figure 1. Annual pan-Arctic net methane emissions from 2000–2016 (XPTEM-XHAM: model with microbial and permafrost dynamics, TEM: default model).

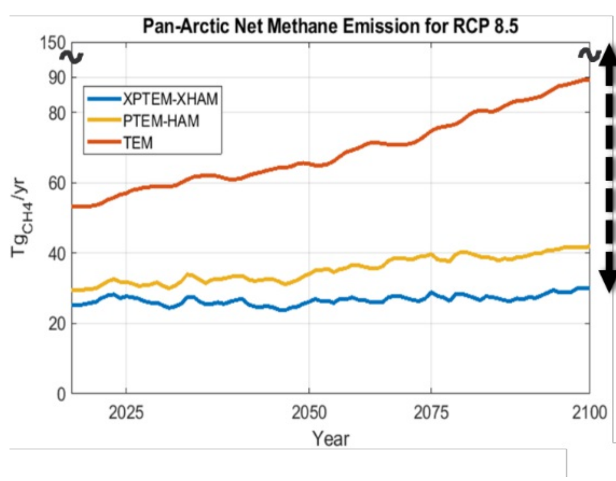

Figure 2. Annual pan-Arctic net methane emission from 2016–2100 under the RCP 8.5 scenario (XPTEM-XHAM: model with microbial and permafrost dynamics, TEM: default model).