Spatial and temporal variation in potential soil CH_4 consumption rates in a northern boreal watershed

Anuliina Putkinen[1,2,3], Maarit Nurminen [1,2], Markku Koskinen[1,2,4], Jimi J Havisalmi[1], Annalea Lohila[1,4], Mari Pihlatie[1,2,5], Lukas Kohl[1,2]

1 University of Helsinki, Department of Agriculture, Environmental Soil Sciences
2 University of Helsinki, Institute of atmospheric and Earth system research (INAR) / Forest research
3 University of Helsinki, Department of Microbiology
3 Finnish Meteorological Institute
4 University of Helsinki, Viikki plant science center (ViPS)

Soil can be sources or sinks of methane (CH_4), depending on the presence of competent microbial communities (methanogens and methanotrophs) and environmental conditions (i.e., redox potentials) that render these processes energetically viable. In this study, we investigated the former by surveying how the potential for the soils to produce or consume CH_4 varied in space (location and soil depth) and time (season) in a northern boreal watershed. To do so, we established a ~2 km hilltop-to-wetland transect between the Kenttärova and Lompolojänkä ICOS stations in Northwestern Finland. We collected soil samples from seven plots along this transect, which cover major vegetation types and relief positions in the Lompolojänkä catchment (spruce/birch and pine forests; hilltop, hillslope, and hillfoot position; drained and undrained peat). Samples were collected from three replicate soil pits at each plot at the beginning, mid, and end of the growing season. We separated soil profiles into >3 generic soil horizons (where possible) or depth increments reaching to at least 25 cm depth at each site. In total, >300 soil samples were collected and >1000 individual incubation experiments were conducted between June and September 2019. Here, we present initial results from high- and low-affinity CH_4 incubations assays conducted with soil samples collected in June and July 2019. For these, CH_4 consumption rates at field moisture were measured under aerobic conditions with a starting CH_4 concentration of 8 (high affinity) or 8000 (low affinity) ppmv. Methane oxidation rates were normalized to soil volume. High affinity methane oxidation varied strongly throughout the dataset, ranging <0.5 to 15 umol CH_4 dm^{-3} d^{-1}. The highest potentials were found in the hilltop and open wetland endpoint of the transect, whereas hillslope and forested peatland site exhibited lower potentials. Within soil profiles, the highest potentials were found in the organic and/or top mineral soils, whereas deeper soil layers exhibited CH_4 oxidation potential only at the open wetland site. We did not detect an overall change in the CH_4 oxidation potential between the early and mid-summer time points, but several sites exhibited a shift of the CH_4 potential towards more shallow soil horizons in at the later sampling event. Low affinity CH4 oxidation potentials up to 6 mmol CH_4 dm^{-3} d^{-1} were detected at the wetland endendpoint, while only minor potentials were detected at other sites. Again, we found a shift towards CH_4 oxidation in more shallow soil layers in the mid compared to the early growth season.