Redox state affects methane flux in a northern boreal flark fen

Markku Koskinen\textsuperscript{1,3,6}, Hanna Finné\textsuperscript{2}, Tarmo Virtanen\textsuperscript{2}, Annalea Lohila\textsuperscript{1,4}, Raija Laiho\textsuperscript{5}, Tuomas Laurila\textsuperscript{1}, and Mika Aurela\textsuperscript{1}

\textsuperscript{1}Finnish Meteorological Institute, Greenhouse Gases Research Group, Helsinki, Finland
\textsuperscript{2}Ecosystems and Environment Research Programme, Faculty of Biological and Environmental Sciences, and Helsinki Institute of Sustainability Science (HELSUS), University of Helsinki, Helsinki, Finland
\textsuperscript{3}INAR Institute for Atmospheric and Earth System Research/Forest Sciences, University of Helsinki, Finland
\textsuperscript{4}INAR Institute for Atmospheric and Earth System Research/Physics, University of Helsinki, Finland
\textsuperscript{5}Natural Resources Institute Finland, Helsinki, Finland
\textsuperscript{6}Environmental Soil Science, Department of Agricultural Sciences, University of Helsinki, Finland

Long-term continuous measurement of reduction-oxidation (redox) potential is an emerging tool for analysing ecosystem status. Redox processes are intrinsically linked to methane (CH\textsubscript{4}) production and consumption in soils. Under highly reducing conditions, acetate and carbon dioxide (CO\textsubscript{2}) are reduced into CH\textsubscript{4}, while at less reducing conditions, CH\textsubscript{4} is readily oxidised into CO\textsubscript{2}. These oxidation processes do not necessarily require oxygen; other electron acceptors such as nitrate (NO\textsubscript{3}) and iron can also be used by microbes. The prevalence of different electron acceptors and donors is reflected in the redox potential of the soil solution which can be measured. Thus measurements of soil redox potential could in principle be used for predicting CH\textsubscript{4} flux.

We measured soil redox potential at 4 depths between 5 and 40 cm continuously over one growing season on nine measurement plots on three different microsites (flark, lawn and string), in a north boreal flark fen, while concurrently measuring CO\textsubscript{2} and CH\textsubscript{4} flux of the same plots using the manual chamber method. Flux measurements were conducted five to seven times per week from late June to late September, 2019. Along with the redox potential, water table level (WTL), air and soil temperature (Tair, Tsoil) and several vegetation characteristics were also measured.

Tsoil was found to be the major control of the momentary CH\textsubscript{4} flux, but after standardizing the flux to 10 C using the Lloyd-Taylor equation, including the soil redox potential was found to significantly (p < 0.001) improve the prediction of the flux over a model incorporating only WTL and momentary Tsoil.

This is an initial step towards inclusion of redox potential as a continuous variable describing the processes active in the soil into CH\textsubscript{4} production/consumption models.