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Rates of heterotrophic respiration and oxidation of atmospheric CH4 in drylands across a global climate and ecosystem gradient

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Soil moisture and temperature collectively regulate the production and consumption of carbon in soils. However, it remains unclear whether this interactive regulation is similar across widely different ecosystems and climates and which environmental factors drive potential differences? With expected changes in both the thermal and hydrological regime of soils globally it is important to obtain experimental data on carbon turnover from widely different environmental settings that can constrain the prediction of soil carbon dynamics.

Our main objective was to investigate the combined effect of soil water and temperature manipulation on heterotrophic respiration and methane oxidation rates in soils from grassland ecosystems across a large geographical scale representing widely different geological histories and ecosystem development trajectories. Thus, soils were sampled across a climate and ecosystem-age gradient in natural and semi-natural shrub and grasslands ranging from Greenland (Arctic), Denmark (temperate) and Australia (subtropical). Furthermore, at the Danish and Australian sites soil samples were also collected under reduced and ambient precipitation.

At low soil water content (<15 % water holding capacity) both processes diminished and showed no temperature sensitivity. However, at higher soil water levels (> 25% water holding capacity) heterotrophic respiration exhibited temperature dependency with no effect of increased water content. Conversely, the methane fluxes were primarily controlled by the soil water content with little temperature dependency. We observed higher responses in the heterotrophic respiration rates at low temperatures and higher optimum water levels for methane oxidation rates in Greenland compared to the Danish and Australian soils. Surprisingly, the optimum temperature for methane oxidation did not differ between sites despite the extreme differences in the ambient climate between the three sites, e.g. Arctic to subtropical. Also, it is noticeable that the methane oxidation and heterotrophic respiration rate in soils with manipulated precipitation reduction were not significantly different to the rates measured in soils for the ambient plots.

These data do show that there are similar patterns in the regulation of oxidation of atmospheric methane in soils by soil water and temperature despite widely different ecosystem developments. However, the site-specific effect was more noticeable for heterotrophic respiration. With this contribution, we would also like to discuss how these data can be used in future discussion about the impact of environmental changes on the carbon turnover in terrestrial ecosystems and how they may be used to inform ecosystem models.