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Rainfall reduction increases soil methane uptake in broadleaf evergreen eucalypt forest – a negative feedback to climate change?

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Well-drained aerated soils are important sinks for atmospheric methane (CH_4), a process driven by CH_4 oxidation through methanotrophic bacteria. Soils in temperate forests ecosystems represent the greatest land based CH_4 sink and soil moisture is one of the key controllers of soil CH_4 flux in these systems. Most climate change models predict a decrease in average rainfall, an increase in extreme rainfall events and an increase in temperatures for mid-latitude and sub-arid regions. However, most of the studies on CH_4 uptake under altered rainfall scenarios have been conducted in the northern hemisphere and have often investigated the effect of extended drought periods rather than the effect of an overall reduction in rainfall upon soil CH_4 uptake. We measured soil CH_4 flux for 18 months after installing a passive rainfall reduction system to intercept 35% of canopy through-fall, as compared to control plots, in a temperate dry-sclerophyll eucalypt forest in south-eastern Australia.

Rainfall reduction caused an average reduction of 14.6% in volumetric water content, a reduction of 18.5% in water filled pore space (WFPS) and a 19.5% increase in air filled porosity. In response to these soil moisture changes, soil CH_4 uptake increased by 38%. Our data indicated that soil moisture was the dominant controlling factor of seasonality in soil CH_4 uptake. This was confirmed by additional soil diffusivity measurements and passive soil warming treatments. Consequently, soil moisture was the single most important factor controlling CH_4 uptake in this forest system explaining up to 80% of the seasonal variability and accounting for the observed rainfall reduction treatment effect. We further tested non-linear functions to describe the relationship between soil moisture and CH_4 uptake and a log-normal function provided best curve fit with soil CH_4 uptake peaking at a WFPS of 15%. This soil CH_4 uptake maximum is much lower than in other ecosystems and might reflect the drought tolerance of local methanotrophic communities. However, applicability of the log-normal function to model CH_4 uptake will have to be evaluated on global datasets.

Soil moisture during our study period rarely fell below 15% WFPS and the observed mean was around 40% WFPS. It is therefore likely that soil CH_4 uptake will increase under reduced rainfall scenarios in the dry-sclerophyll forest zone of Australia as a consequence of climate change.