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Soil respiration (CO_2 efflux) response to spatio-temporal variability of soil water repellency

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Soil water repellency (SWR) is a common feature of many soils which restricts water infiltration and movement within the soil. SWR is expected to become more spread according to current climatic prediction, but its effect on soil carbon dynamics and specifically on soil CO_2 fluxes is still not clear. Based on previous laboratory experiments it has been suggested that water repellency reduces soil respiration, but the responses of soil CO_2 efflux to naturally varying hydrological conditions created by SWR are not yet known. This is the first field-based study testing the hypothesis that water repellency indeed reduces soil CO_2 efflux. In situ field measurements of soil CO_2 fluxes, temperature, water contents and water repellency were carried out over three consecutive years at a grassland and pine forest site under the humid temperate climate of the UK.
SWR was observed for the majority of the warmer period, but exhibited high spatial variability. Soils showed similar levels of extreme water repellency only on a few occasions following long dry spells and this indeed resulted in reduction in CO_2 efflux. Spatially patchy SWR with variable soil moisture content induced the highest respiration rates, significantly higher than when SWR was absent. This rather unexpected behaviour can be explained by SWR-induced preferential flow which created flow paths with water and nutrients supply to the microorganisms, while water repellent zones provided air-filled pathways to facilitate soil-atmosphere gas exchanges.
This study demonstrates that SWR can have contrasting effects on CO_2 fluxes and, when spatially-variable, enhance CO_2 efflux.