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High summer precipitation reduces soil methane sink capacity and alters decomposition processes in a mature temperate forest

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Climate change is expected to alter global precipitation patterns, with unknown impacts on biodiversity and ecosystem functioning. Temperate forests are one of the largest terrestrial carbon stocks, acting as sinks for greenhouse gases such as carbon dioxide and methane thus playing a major role in ameliorating global warming. Predicted changes to precipitation intensity, duration and timing under future climates are likely to result in the alteration of soil moisture dynamics in forest soils. This will impact soil microbial functions, with shifts from oxic to hypoxic or anoxic conditions which could affect microbial metabolism and microbially-mediated nutrient cycling. The impacts of these changes on the terrestrial carbon balance under current and future atmospheric carbon dioxide levels is currently not known. Here, we use a novel *in situ* approach to simulate high rainfall in soil mesocosms within a mature temperate oak-dominated (*Quercus robur*) forest in Staffordshire, UK (Birmingham Institute of Forest Research Free-Air Carbon Dioxide Enrichment facility) where atmospheric CO_2 levels are elevated 150 ppm above ambient levels. We show that an 8-week period of elevated rainfall and volumetric soil moisture (~ 30% increase in amended mesocosms vs controls) had significant impacts on soil functioning. The forest soil methane sink was significantly reduced in the high rainfall treated soils by ~ 21-67%, resulting in greater methane accumulation in the atmosphere, with no recovery 4 weeks post-event. Using 16S rRNA amplicon sequencing and qPCR approaches, we show how bacterial and archaeal diversity respond to altered precipitation regimes and show significant changes in the abundance of methanotrophic and methanogenic communities. The activities of soil extracellular enzymes, involved in the breakdown of organic carbon, nitrogen, and phosphorus compounds, were reduced during the high rainfall treatment. Our results demonstrate that important climate feedbacks could occur during modest alterations in precipitation which should be considered in climate models and forestry management plans.