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Impact of repeated dry-wet cycles on soil greenhouse gas emissions, extracellular enzyme activity and nutrient cycling in a temperate forest

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Climate change research predicts that both frequency and intensity of weather extremes such as long drought periods and heavy rainfall events will increase in mid Europe over the next decades. Soil moisture is one of the major factors controlling microbial soil processes, and it has been widely agreed that feedback effects between altered precipitation and changed soil fluxes of the greenhouse gases CO_2, CH4 and N2O could intensify climate change.

In a field experiment in an Austrian beech forest, we established a precipitation manipulation experiment, which will be conducted for 3 years. We use roofs to exclude rainfall from reaching the forest soil and simulate drought periods, and a sprinkler system to simulate heavy rainfall events. We applied repeated dry-wet cycles in two intensities: one treatment received 6 cycles of 1 month drought followed by 75mm irrigation within 2 hours, and a parallel treatment received 3 cycles of 2 months drought followed by 150mm irrigation within 3 hours. We took soil samples 1 day before, 1 day after and 1 week after rewetting events and analyzed them for soil nutrients and extracellular enzyme activities. Soil fluxes of CO_2, N2O and CH4 were constantly monitored with an automated flux chamber system, and environmental parameters were recorded via dataloggers. In addition, we determined fluxes and nutrient concentrations of bulk precipitation, throughfall, stemflow, litter percolate and soil water. Next we plan to analyze soil microbial community composition via PLFAs to investigate microbial stress resistance and resilience, and we will use ultrasonication to measure soil aggregate stability and protection of soil organic matter in stressed and control plots.

The results of the first year show that experimental rainfall manipulation has influenced soil extracellular enzymes. Potential phenoloxidase activity was significantly reduced in stressed treatments compared to control plots. All measured hydrolytic enzymes (cellulase, chitinase, phosphatase and protease) and phenoloxidase responded strongly to rewetting events with significantly increased activities. Furthermore, we observed a pulsed release of inorganic nitrogen which resulted in high concentrations of NH4 and NO_3 in the first 24h after soil rewetting, especially in summer when soil temperatures were high. Emissions of CO_2 were increased in the first 24 to 48h after rewetting, and then slowly decreased again. Overall, our results indicate that repeated dry-wet cycles strongly influence microbial soil processes, even in the first year of experimental rainfall manipulation. The next 2 years will show whether these changes are permanent, or if the system adapts to the new precipitation regime.