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Impact of repeated dry-wet cycles on soil CO_2 efflux in a beech forest

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Climate change research predicts that both frequency and intensity of weather extremes such as severe droughts and heavy rainfall events will increase in mid Europe over the next decades. Because soil moisture is one of the major factors controlling microbially-driven soil processes, a changed moisture regime will impact soil organic matter (SOM) decomposition and nutrient cycling. This in turn can lead to feedback effects between altered precipitation and changed soil CO_2 fluxes which can intensify climate change. Soil microorganisms can go into a state of dormancy or form inactive cysts to protect themselves from osmotic stress during soil drying. However, severe droughts increase microbial mortality which slows down SOM decomposition and decreases soil CO_2 efflux. The rewetting of dry soil, on the other hand, causes large CO_2 emissions, which is also known as the "Birch effect". Until today it is not clear whether these CO_2 peaks outweigh the drought-induced decrease of total CO_2 efflux.

To investigate the impact of repeated dry-wet cycles on soil CO_2 efflux we are conducting a precipitation manipulation experiment in a temperate Austrian beech forest. Roofs exclude rainfall and simulate drought periods, and heavy rainfall events are simulated with a sprinkler system. We apply repeated dry-wet cycles in two intensities: one treatment receives 6 cycles of 1 month drought followed by 75mm irrigation, and a parallel treatment receives 3 cycles of 2 months drought followed by 150mm irrigation. Soil CO_2 efflux is constantly monitored with an automated flux chamber system, and environmental parameters are recorded via dataloggers.

Our results show that droughts significantly reduce soil CO_2 effluxes, and that the reductions depend on the length of the drought periods, with longer droughts leading to stronger reductions of CO_2 effluxes. In the first 24 to 48h after rewetting, CO_2 emissions strongly increased, and then slowly decreased again. Soil CO_2 efflux was correlated exponentially with soil temperature at volumetric soil moisture contents >15%. In dryer soils, we found a hyperbolic relationship between soil moisture and residuals of the exponential relationship between CO_2 efflux and soil temperature. Cumulative soil CO_2 effluxes significantly decreased in dry-wet treatments compared to control plots, which indicates that the CO_2 pulses after rewetting did not outweigh the reduction in CO_2 efflux during drought periods. Furthermore, cumulative soil CO_2 effluxes were lower in the treatment with extended drought periods, which shows that magnitude and frequency of extreme events also influence soil CO_2 emissions.