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Thresholds in soil response to water stress: intensity and duration of dry-wet cycles induce differential soil C and bacterial diversity dynamics

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After the wetting of dry soils, a CO_2 flush (known as the 'Birch effect') is often observed. Although the Birch effect can often result in large CO_2 fluxes, the process is not sufficiently well understood to predict its intensity. In particular, the impact of dry-wet cycles on microbial communities is poorly understood, as are the consequences of the possible changes for soil functioning.
Using microcosm-based experiments, we investigated different climate change scenarios, such as drying periods of different durations (with co-variation of drying intensity and drought duration) and different rainfall intensities. The effects of four dry-wet cycles on the (i) immediate intensity of the Birch effect, (ii) rate of return to basal C mineralisation (functional resilience), (iii) total amount of CO_2 released during a 5-month incubation and (iv) the dynamics of bacterial diversity were determined. Bacterial diversity was measured by pyrosequencing.
The CO_2 flush increased as a function of drying intensity, drought duration and wetting intensity but was not affected by the number of dry-wet cycles. However, the functional resilience was slower after the first dry-wet cycle than subsequent cycles, suggesting an adaptation of the microbial communities to water-stress. However, this was not associated with a higher stability of bacterial community since the pyrosequencing data showed that drying decreased bacterial diversity after each dry-wet cycle, but only if a threshold of minimal moisture is exceeded. These modifications were permanent over the long term and suggest that the communities were characterised by functional redundancy. Moderate droughts had no effect on overall CO_2 emissions but severe droughts led to a lower loss of soil C due to the absence of mineralisation during the longer periods of desiccation that was not compensated by over-mineralisation during Birch effect. The study highlighted moisture threshold beyond which it can be observed a Birch effect and a decline of microbial diversity.