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Effects of summer drought on carbon dynamics in mountain grassland

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Mountain ecosystems are considered as particularly vulnerable to disturbance and are exposed to comparatively fast changes in climate and land use. Mountain grasslands cover about 8% of the terrestrial surface and hold 15% of the carbon (C) contained in soils. We studied effects of sustained summer drought on the C dynamics of a mountain meadow at 1820 m in the Austrian Central Alps, as based on a series of rainfall exclusion experiments. Aboveground net primary production, net ecosystem exchange of CO2 (NEE), gross primary productivity and ecosystem respiration showed a consistent reduction with increasing progression of drought. Drought diminished canopy photosynthesis more strongly than ecosystem respiration. After the third subsequent year of simulated summer drought memory effects on NEE were observed, that were likely due to shifts in the abundance of species, whose stomatal response to drought differed considerably. Belowground net primary production was not consistently affected by drought. Soil respiration and CO2-concentrations across the soil profile were significantly reduced by drought, though soil respiration responded only when a critical threshold of soil moisture was exceeded towards the end of the drought period. Autotrophic (i.e. root and rhizosphere) components of soil respiration showed a stronger decrease than heterotrophic (i.e. bulk soil microbial) components. The first rainfall event after the simulated drought triggered a peak in soil CO2 emissions which lasted for several hours and was, surprisingly, more pronounced for autotrophic than for heterotrophic components. Detailed analyses of mechanisms underlying the observed changes, as based on in situ isotopic labeling studies and model analyses of the production and diffusion of CO2 across the soil profile are currently being elaborated. We conclude that 1) summer drought may potentially alter the carbon balance of alpine grassland towards decreasing the C sink strength, 2) component processes are governed by different critical thresholds, and 3) repeated drought may induce memory effects on the C dynamics in mountain grassland.