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Effects of recurring summer droughts on ecosystem photosynthesis and respiration in a mountain grassland

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Climatic changes in mountain regions play a key role in current and future grassland ecosystem processes. It is currently expected that droughts and heatwaves will become more frequent in a changing climate. All around the world mountain regions have been labelled as sensitive zones, where declining water availability and increasing temperature are expected to increase the vulnerability of these ecosystems. However, the effects of such extreme events on ecosystem carbon (C) fluxes and their coupling in temperate and so far non-water limited Alpine grasslands are not yet well understood. We studied effects of recurring summer drought on the C dynamics of a mountain meadow at 1820 m and an abandoned grassland at 2000 m in the Austrian Central Alps. The aim of the study was (1) to analyse the multiannual effect of drought on net ecosystem CO_2 exchange (NEE) and its major component processes, i.e. gross primary productivity (GPP) and ecosystem respiration (Reco), and (2) to trace drought effects on the use of recent C in soil respiration. We tested the hypothesis that drought reduces NEE, GPP and Reco and the ratio of GPP / Reco and causes a reduction in the use of recent photoassimilates in belowground respiration. At each study site, exclusion of rainfall was achieved by establishing rain-out shelters for a period of two months (June, July), while control plots remained exposed to natural precipitation. To trace the fate of recent C from assimilation to respiration $13CO_2$ pulse-labelling was carried out at the meadow site, and the carbon isotope composition of soil respired CO_2 was continuously monitored with an open dynamic-chamber system coupled with a quantum cascade laser. Our results showed that at both sites NEE, GPP and Reco showed a consistent reduction with reduction in soil water level. Drought reduced ecosystem respiration to a lesser extent than photosynthesis. We observed memory effects on all flux processes after 3 years of recurring drought on the mountain meadow, which was likely due to shifts in the abundance of dominant species. Within the first 30 days after labelling, the contribution of recent C to the main component process of ecosystem respiration (soil respiration) was slightly reduced in the drought plots. We conclude that 1) a summer drought may potentially alter the carbon balance of mountain grasslands towards decreasing
photosynthesis and assimilation area, whereas 2) repeated drought may lead to adaptation of the ecosystem which reduces the drought response of C fluxes, and 3) summer drought may reduce the contribution of recent C to belowground respiration.