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Effect of summer drought on the coupling of photosynthesis and soil respired CO_2 in the current and future climate

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Belowground carbon allocation acts as a key determinant of the fate of carbon in terrestrial ecosystems. Climate extremes such as drought exert a major impact on the ecosystem carbon balance by affecting carbon allocation and thus the relationship of assimilated and respired carbon. Drought has been shown to slow down the allocation of recently assimilated carbon belowground and it thereby reduces the coupling of photosynthesis and soil respiration. However, it is still unclear how extreme drought will affect the coupling of photosynthesis and soil respiration in a warmer climate under elevated atmospheric CO_2. While climate warming is expected to enhance drought-induced reductions in soil respiration, elevated CO_2 has been suggested to generally enhance soil respiration and mitigate soil moisture reductions. Yet, the interactive effects of drought, warming and elevated CO_2 are so far poorly understood.

Here we study the impact of drought on the coupling of photosynthesis and soil respiration in a managed C3 grassland under current versus future climate conditions. We simulated the future climate by experimentally increasing the air temperature by 3˚C and atmospheric CO_2 concentration by 300ppm above ambient. We performed two $^{13}CO_2$ pulse-labeling experiments to trace the fate of carbon from photosynthesis to soil respiration during the drought and the recovery period. Our preliminary results indicate that elevated CO_2 and climate warming increased soil respiration in the absence of drought. Furthermore, soil respiration was reduced by drought and this effect was enhanced by the combination of elevated CO_2 and climate warming. Our preliminary results also indicate that during peak drought the proportional amount of recent carbon respired belowground was reduced by drought. While this response was primarily driven by a reduction of relative amount of recently assimilated carbon in the current climate, it was mostly caused by the reduction in soil respired CO_2 under warming and elevated CO_2. Also during rewetting, the mechanism underlying the emission of recent carbon was found to be different between current and future climate scenarios. We conclude that the drought responses underlying the coupling of photosynthesis and soil respired CO_2 will likely change in future climate.