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Response of water fluxes and biomass production to climate change in permanent grassland soil ecosystems

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The effects of climate change on ecosystem productivity and water fluxes have been studied in various types of experiments, but it is still largely unknown whether and how the experimental approach itself affects the results of such studies. We use data from high precision weighable lysimeter from two contrasting experimental approaches to determine and compare the responses of water fluxes and aboveground biomass to climate change in low mountain range permanent grasslands. The first approach is based on a controlled increase in atmospheric CO_2 concentration and surface temperature (type manipulative). Space-for-time substitution along a gradient of climate conditions was used in a second approach (type: observational). The Budyko framework was used here to determine if the soil ecosystem is energy or water limited.

Under energy-limited conditions and elevated temperature, actual evapotranspiration increased, while seepage, dew, and aboveground biomass decreased. Elevated CO_2 mitigated the effects on actual evapotranspiration. Under water-limited conditions, increased temperature decreased actual evapotranspiration, and aboveground biomass correlated negatively with increased drought.

Our results reveals that the responses of soil water fluxes and biomass production of both experimental approaches depend mainly on the status of ecosystems in terms of energy or water limitation. To better understand ecosystem responses to climate change and identify potential tipping points, climate change experiments must include sufficiently extreme boundary conditions so that responses to single and multiple forcing factors can be comprehensively studied. Manipulative and observational climate change experiments complement each other well in this regard, and thus the approaches should be combined in future research on climate change impacts on grasslands.