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Impacts of climate change on carbon exchange processes of grassland ecosystems

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Given the huge carbon stocks in vegetation and soils of grassland ecosystems, their high vulnerability to climate change have a profound effect on ecosystem carbon exchange with the atmosphere and in turn feedback with future climate warming. To investigate the effects of climate change on carbon processes, our presentation includes two parts: 1) a comprehensive meta-analysis on impacts of warming on grassland carbon cycling and 2) results from experimental work conducted at montane grasslands in the Bavarian Alps/ pre-Alps TERENO Observatory, Germany.

Various experiments so far showed diverse effects of warming on carbon exchange processes in grassland ecosystems worldwide. For a more comprehensive understanding of those contradictory responses, in this study a most detailed meta-analysis including 550 datasets was applied. Instead of current available review studies mainly comparing impacts of climate change on carbon exchange processes between different ecosystems (e.g. grassland and forest) we evaluated potentially diverging effects of climate change between "average" grassland and different grassland biomes, i.e. alpine, temperate and semi-arid. Our results show that experimental warming generally stimulated carbon fluxes in grassland ecosystems both for assimilation (ANPP + 7.6 %, BNPP +11.6% NPP) + 15.4%) and dissimilation processes (soil respiration (+9.5%). However, responses of carbon fluxes varied among the three grassland biomes, with higher vulnerability of alpine compared to temperate and semi-arid grasslands. Overall, NEE was significantly increased by 25.0% in alpine grasslands by warming, while the changes in temperate (-6.0%) and semi-arid grasslands (1.1%) were much smaller and insignificant. With regard to the duration of the climate change experiment, warming initially (year 1-3) increased ANPP and Rs, but this response weakened with longer exposure to climate change conditions.

To in-situ investigate impacts of climate change on montane grassland carbon exchange processes grassland in the Bavarian Alps/ pre-Alps TERENO Observatory, lysimeters (diameter approx. 1 m, depth 1.4 m) were translocated from higher elevation to sites at lower elevation. Depending on different management regimes (cutting and manuring events) half of the lysimeters were intensively and the other half extensively management. Within a two-year period, we recorded carbon fluxes of gross primary production (GPP), ecosystem respiration (Reco) and net ecosystem exchange (NEE) with manual transparent and dark chamber measurements, as well as grass height and biomass. Results revealed, climate change slightly increased GPP resulting in increased plant productivity (NPP) in extensive and intensive treatments. As Reco increased even more than GPP, NEE was slightly lower under climate change conditions, particularly under hot and dry soil conditions. From measured flux data and environmental conditions, we developed empirical models using e.g. soil temperature, air temperature, soil moisture, and photosynthetically active radiation, for prediction of daily and annual carbon fluxes of the respective treatments.