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Management intensity modifies the effects of climate change on carbon exchange processes of grassland ecosystems

Na Wang (1), Klaus Butterbach-Bahl (1,2), and Ralf Kiese (1)

(1) Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology (KIT), Garmisch-Partenkirchen, Germany, (2) Mazingira Centre, International Livestock Research Institute (ILRI), Nairobi, Kenya

Given the huge carbon (C) stocks in vegetation and soils of grassland ecosystems, their high vulnerability to climate change have a profound effect on ecosystem C exchange with the atmosphere and in turn feedback with future climate warming. Different management intensities may contribute to the responses of ecosystem C exchange to climate change.

To investigate the effects of climate change and management intensities on C processes in grasslands, an in-situ climate change simulation experiment was carried out in the TERENO pre-Alpine Observatory in southern Germany (Kiese et al., 2018). A total of twelve large lysimeters (area 1 m2, depth 1.4 m) were translocated from higher elevation (control sites) to sites at lower elevation (climate change sites with higher temperature and slightly lower precipitation). Depending on different management regimes (frequency of cutting and manuring events), half of the lysimeters were intensively and the other half extensively managed.

Within a two year time period, net ecosystem exchange (NEE) and ecosystem respiration (Reco) were measured at both sites with a transparent/ dark chamber (1m2 area, 0.7m height); and gross primary production (GPP) was calculated accordingly (GPP=Reco+NEE). Grass height, soil moisture and soil temperature were also recorded. During each measurement campaign, NEE and Reco were measured 6-9 times over the course of a day, allowing us to determine diurnal patterns of fluxes. Based on measured flux data and environmental conditions, we developed regression 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.

Results revealed, that climate change increased GPP and Reco for both intensive and extensive managed grasslands, but the resulting effects of climate change on NEE differed between two management intensities. At intensive managed lysimeters, as climate change increase Reco (from 19.5±1.4 to 23.2±1.3 t C/ha/yr) more than GPP (from 19.9±1.6 to 23.0±0.8 t C/ha/yr), the sign of NEE changed into C loss from control (-0.5±2.2 t C/ha/yr) to climate change (0.2±1.9 t C/ha/yr), particularly under hot and dry soil conditions. The opposed was found for extensive managed lysimeters, that is, under warming the increase of GPP (from 20.3±0.4 to 22.4±1.4 t C/ha/yr) is higher than of Reco (from 20.0±1.6 to 21.9±2.4 t C/ha/yr), leading to higher NEE (net C gain) under climate change (-0.6±3.1 t C/ha/yr) than control conditions (-0.3±1.6 t C/ha/yr).