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Impact of climate change on GHG emissions of (pre-) alpine grassland ecosystems under intensive and extensive management – a climate sequence lysimeter study

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Due to cool and moist climatic conditions alpine grassland soils of moderate elevation are rich in soil organic carbon and associated nitrogen. In the framework of an in-situ climate change experiment we test the hypothesis that soil organic carbon and nitrogen are either volatilized (GHG emissions) or leached with seepage water due to increase in temperature. Field investigations are carried out in the (Pre-) Alpine TERENO Observatory covering several research sites (including ICOS sites) in South-Bavaria, Germany. IMK-IFU has installed 36 weighable lysimeters with undisturbed intact grassland soil cores (diameter 1m, depth 1.4m) and is operating them at three sites differing in altitude and thus climatic conditions (850m, 750m, 600m) since 2011. Lysimeters were partly translocated from higher elevation to sites at lower elevation and other soil cores still staying at the sites as controls. In addition to the space for time in-situ climate change approach the total of 36 lysimeters are split into treatments of intensive and extensive grassland management. GHG exchange was measured by manual (850m site) but also with two novel automatic robot chamber systems (750m, 600m) connected to QCLs for simultaneous detection of CO_2, N2O, and CH4 concentration changes in chamber headspace. GHG flux monitoring was supplemented by NEE measurements with transparent chambers since 2014.
Climate change, generally stimulated plant growth (according to biomass sampling after cutting events) and soil C and N turnover leading to increased soil CO_2 emissions and an increased uptake of atmospheric CH4. N2O emission were generally low and slightly increased in spring, summer and autumn but significantly decreased during the winter period under global change conditions, the latter due to lower intensity and frequency of frost-thaw events. The main gaseous nitrogen component emitted from the grassland ecosystems was N2 which also showed a much stronger increase with climate change than N2O. Furthermore, climate change lead to a significant increase in nitrate leaching, whereas leaching of ammonium and DON as well as DOC were hardly affected. Climate induced changes in the GHG balance of (pre-) alpine grassland ecosystems are mainly triggered by alteration of ecosystem CO_2 exchange since magnitude of CH4 (mainly uptake) and N2O exchange, even regarding their much higher global warming potential are of lower importance. Overall, impacts of climate change on ecosystem C and N losses seem to be more severe under extensive management.