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# Impacts of climate and management on water balance and nitrogen leaching from montane grassland soils

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The impacts of climate and management on the water balance and nutrient leaching of montane grasslands have rarely been investigated, though such ecosystems may represent a major source for ground and surface water nitrates. In this study nitrogen (nitrate, ammonium, dissolved organic nitrogen) and dissolved organic carbon leaching as well as water balance components (precipitation, evapotranspiration, and groundwater recharge) were quantified (2012-2014) by means of replicated (N=3 per site/ treatment) measurements of weighable grassland lysimeters (1 $m^2$ area, 1.2 m soil depth) at three sites (E860: 860 m a.s.l., E770: 770 m a.s.l. and E600: 600 m a.s.l.) in the pre-alpine region of S-Germany. Two grassland management strategies were investigated: a) intensive management with 5 cuts per year and cattle slurry application rates of 280 kg N ha-1 yr-1, and b) extensive management with 3 cuts per year and cattle slurry application rates of 56 kg N ha-1 yr-1. Our results show that at E600, the site with highest air temperature (8.6 °C) and lowest precipitation (981.9 mm), evapotranspiration losses were 100.7 mm higher as at the E860 site, i.e. the site with lowest mean annual air temperature (6.5 °C) and highest precipitation (1359.3 mm). On the other hand groundwater recharge was substantial lower at E600 (-440.9 mm) as compared to E860. Compared to climate, impacts of grassland management on water balance components were negligible. However, intensive management significantly increased mean total nitrogen leaching rates across sites as compared to extensive management from 2.6 kg N ha-1 year-1 (range: 0.5-6.0 kg N ha-1 year-1) to 4.8 kg N ha-1 year-1 (range: 0.9-12.9 kg N ha-1 year-1). N leaching losses were dominated by nitrate (64.7 %) and equally less by ammonium (14.6 %) and DON (20.7 %). The rather low rates of N leaching (0.8 – 6.9 % of total applied N) suggest a highly efficient nitrogen uptake by plants as measured by plant total N content at harvest. Moreover, plant uptake was often exceeding slurry application rates, suggesting further supply of N due to soil organic matter decomposition. The low risk of nitrate leaching of cut grassland on non-sandy soils with vigorous grass growth may call for a careful re-evaluation of the maximum fertilization rate of 250 kg N ha-1 as defined by the EU Nitrate and Water Framework Directive.