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# Extreme conditions in the vadose zone of an alpine grassland revealed by lysimeter measurements

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The year 2018 was the warmest within 251 years of measurements, furthermore within the northern parts of the Austrian Alps, this year was also exceptionally dry (ZAMG, 2018). The aim of this study is to quantify the impact of these extreme weather conditions on soil hydrological variables such as water content and matric potential and the soil water balance as well as on plant growth of a managed grassland within the Enns valley situated in the northern Alps. For this purpose, data from a high precision weighable lysimeter equipped with tensiometers and time domain reflectory (TDR) probes at several depths were analyzed. The dynamics of the state variables and water fluxes during the vegetation period of the extreme year 2018 were compared to those of the year 2016, which is considered to represent average weather conditions at the study site.

The tensiometer probes showed significantly lower matric potentials for the summer 2018 compared to 2016. The number of days where the matric potential was below field capacity (< -300 hPa) at a depth of 50 cm is 108 in the observation period 2018, whereas it was never below field capacity at the same depth in 2016. Thus, in response to extremely dry conditions the plants resort to soil water at a depth that in other years is unaffected by root water uptake. At the depth of 140 cm the matric potentials were approximately -200 hPa in the summer months of 2018 in contrast to those of 2016 with a constant matric potential of -55 hPa.

In 2018, the water content at a depth of 50 cm decreased from 33% in April to 25% in July and remained constant afterwards. In 2016, the water content at the same depth ranged between 30% and 35% and showed strong fluctuations in summer. In 2018, at the depth of 30 cm the water content decreased from 40% in April to 27% in June and reached a minimal value of 25% in August, whereas in 2016 the water content in 30 cm depth ranged between 33% to more than 40% the whole summer.

In the year 2018, the calculated precipitation and evapotranspiration rates constituted only 635 mm and 623 mm, respectively. Consequently, the seepage water counted from April to October 2018 was zero. In contrast, the year 2016 showed higher precipitation of 800 mm and lower evapotranspiration of 530 mm. Thus, the cumulative seepage reached an end value of 75 mm in 2016.

In summary, the measurements showed that the vegetation period was exceedingly dry for such an alpine grassland site. Surprisingly, soil water contents and matric potentials were extremely low particularly at great depths. Since the beginning of the measurements in the year 2012 such low matric potentials have never been observed. Our findings suggest that an increasing duration and intensity of dry spells in a warming climate can potentially cause depletions of the soil water storage that might adversely affect plant growth even in regions where water is currently not a limiting factor.