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Tracing dew and fog water inputs into temperate grassland using stable water isotopes

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Dew and fog have proven to be essential water sources for plants across many Earth's ecosystems. Under climate change with more frequent no-rain days expected in summer, the inputs of dew and fog on short-statured temperate grassland species are expected to become more important as an additional water source. In 2018, Switzerland experienced the driest April to August period of the last five decades. Our research using stable water isotopes investigates how dew and ground radiation fog affected Swiss grasslands in the extreme summer 2018 based on three intensive observation nights of dew and fog. Focusing on an intensively managed grassland located at a valley bottom close to Chamau (CH-CHA) in Switzerland, we measured the isotopic composition (δ^2H and δ^{18}O) of near-surface atmospheric water vapour with a cavity ring-down spectrometer (Picarro L2130-i), and the isotopic composition of the droplets on the leaf surface. Combining the water isotopes with eddy-covariance and meteorological measurements, we analysed the isotope dynamics and fractionation during these three dew and fog nights. Our results indicated that during dew and fog formation, water vapour δ^2H and δ^{18}O gradually decreased under saturated and even slightly supersaturated conditions, but fluctuated under unsaturated conditions. The isotopes of the sampled droplets on the leaf surfaces deviated from the expected isotopic composition based on water vapour under the equilibrium fractionation assumption. During dew and ground radiation fog nights, condensed water was a mix from two sources, atmospheric water vapour and vapour flux from the ground to the foliage. Condensation processes were accompanied by the evaporation from leaf surfaces and the diffusion in the supersaturated layer above the leaf surfaces. This caused non-equilibrium fractionation of water isotopes, seen in the fluctuation of water vapour isotopes and in the observed deviation in the sampled droplets from equilibrium liquids of water vapour. Thus, the isotopic approach is complementary to the often employed micro-lysimetric approach and helps to understand the dynamics and the sources of water vapour during dew and ground radiation fog formation.