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Evaporated samples do not an evaporation line make

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Stable water isotopes are often used to investigate the ecohydrological partitioning of water between evapotranspiration and runoff. The kinetic fractionation induced by evaporation leaves a characteristic signature in the isotopic composition of residual waters, so evaporation effects can be easily detected in a dual-isotope plot. Indeed, in dual-isotope space, evaporated waters plot below the ‘Local Meteoric Water Line’ (LMWL) that describes precipitation. Numerous isotopic studies have observed that soil water samples also plot below the LMWL, suggesting that the soil water has typically undergone significant evaporative fractionation. Soil water samples also often plot along linear patterns in dual-isotope space, such that a trendline can typically fit the data with rather low scatter. These are often termed "evaporation lines", and used to infer the isotopic composition of the putative precipitation source of the soil water. Here we use numerical simulations based on well-known isotope fractionation theory to show that these trendlines are unlikely to reflect true “evaporation lines”, and they typically do not originate from the mean source water. Instead they are artifacts of the seasonality in evaporation and in the isotopic composition of precipitation. Evaporation rates predicted by such lines are likely more depleted than the ‘true’ source water, particularly in regions with strong seasonality in precipitation isotopic composition and evaporation. These results suggest that the interplay between precipitation seasonality, evaporative fractionation, and source mixing should be carefully taken into account when interpreting the isotopic composition of soil water samples.