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Soil Moisture Drought in Europe: A Compound Event of Precipitation and Potential Evapotranspiration on Multiple Timescales

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Compound events are extreme impacts that depend on multiple variables that need not be extreme themselves. We analyse soil moisture drought as a compound event of precipitation and potential evapotranspiration (PET) integrated over multiple time scales related to those which meteorological drought and heat waves occur over. Drought indices that incorporate PET to account for the effect of temperature on drought conditions are sensitive to global warming. However, as evapotranspiration (ET) is moisture limited in dry climates, the use of such drought indices have often been criticised. We therefore assess the relevance of the contributions of both precipitation and PET to the estimation of soil moisture drought in wet, transitional and dry climates in Europe.

Applying a statistical model based on pair copula constructions to data from Fluxnet sites, we find at all locations that precipitation exerts the main control over soil moisture drought. At wet sites, PET is additionally required to explain the severity as well as the onset and persistence of drought events when integrated over short and long time scales respectively. At dry sites, where ET is moisture limited in summer, PET does not improve the estimation of soil moisture. Furthermore, an increased probability of extremely high PET in dry conditions found at many dry sites shows little relevance to the estimation of low soil moisture values.

In dry climates, increases in drought severity as measured by indices incorporating PET may therefore not indicate further drying of soil but the increased availability of energy that can contribute to other environmental hazards such as heat waves and wildfires. We therefore highlight that drought indices including PET should be interpreted within the context of the climate and season in which they are applied in order to maximise their value at a regional level where the impacts of drought are felt.