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Future trends in global water vs. energy-controlled evaporative regimes

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Water and energy availability govern the exchange of carbon, energy and water between the land surface and the atmosphere and therefore exert influence on near-surface weather. Roughly one can distinguish between two evaporative regimes: One limited by available energy (under wet conditions) and one limited by available soil moisture (under dry conditions). The transition between these evaporative regimes has been studied on local to global scales using observational and modelled datasets. This revealed the complexity of defining this transition, as it varies both in space and time and is sensitive to climate, soil and vegetation characteristics.

In this study, we characterized this transition by comparing the correlations of evaporation anomalies with (i) soil moisture anomalies (proxy for strength of water control) and (ii) temperature anomalies (proxy for strength of energy control). In the first step, we use observation-based data to derive global patterns of evaporative regimes and establish that the regime transition is sensitive to not only long-term average soil moisture, but also long-term average temperature. Analyzing historical and future climate model simulations from the Coupled Model Intercomparison Project (CMIP6), we found that the ensemble mean of the CMIP6 models produces similar global patterns and sensitivities to energy and water availability. However, there is ample disagreement between results of individual models, with the largest spread around the transition zones. Further, the disagreement between individual models on the total area of water-limited regions increases gradually in time from historical to future experiments. In the next step, we attribute trends in evaporative regimes to trends in water and energy availability, CO_2 and vapor pressure deficit. This research reveals how global climate change translates into regional-global scale trends in water- vs. energy-controlled evaporative regimes. Our observational results can constrain modelled global evaporative regimes and inform future model development to decrease the substantial spread across the present model ensemble.