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Sensitivity of potential evaporation estimates to 100 years of climate variability

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Evaporation from the vegetated surface is the largest loss term in many, if not the most, water balance studies on earth. As a consequence, an accurate representation of evaporation fluxes is required for appropriate quantification of surface runoff, the soil moisture budget, transpiration, recharge and groundwater processes. However, despite being a key component of the water balance, evaporation figures are usually associated with large uncertainties, as this term is difficult to measure or estimate by modeling.

Many modeling frameworks have used the concept of potential evaporation, often estimated for different vegetation classes by multiplying the evaporation from a reference surface ('reference evaporation') with crop specific scaling factors ('crop factors'). Though this two-step potential evaporation approach undoubtedly has practical advantages, the empirical nature of both reference evaporation methods and crop factors limits its usability in extrapolations under non-stationary climatic conditions. We quantified the sensitivity of potential evaporation estimates for different vegetation classes using the two-step approach when calibrated using a non-stationary climate. We used the past century's time series of observed climate, containing non-stationary signals of multi-decadal atmospheric oscillations, global warming, and global dimming/brightening, to evaluate the sensitivity of potential evaporation estimates to the choice and length of the calibration period. We show that using empirical coefficients outside their calibration range may lead to systematic differences between process-based and empirical reference evaporation methods, and systematic errors in estimated potential evaporation components.

Our hydrological models are to varying extent regression models, which limits their general applicability, and the estimation of potential evaporation is closely linked to climate variability. With our analysis, we want to raise awareness and to provide a quantification of possible systematic errors that may be introduced in estimates of potential evaporation and in hydrological modeling studies due to straightforward application of i) the common two-step approach for potential evaporation specifically, and ii) fixed instead of time-variant model parameters in general. Quantification of errors provides a possibility to correct potential evaporation calculations and to rate them for their suitability to model climate conditions that differ significantly from the historical record, so-called no-analogue climate conditions.