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The best way to estimate potential evaporation – selection of an optimal method using eddy-covariance data across the globe

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Potential evaporation (Ep) is commonly understood as the volume that would evaporate under unconstrained surface water availability. It is a variable that is recursively used in hydrological models and drought monitoring systems. However, multiple interpretations of Ep exist that reflect on a diverse range of methods to calculate it. Because these different methods may result in drastically different estimates of Ep, the latter can be responsible for large uncertainties in hydrological simulations and drought forecasts.

The aim of this study is to revisit and evaluate the most common Ep formulations based on field observations, and to advice on the most suitable methods, from ecosystem to global scales. For this purpose, we use eddy-covariance measurements at 107 sites from the FLUXNET2015 archive, covering 11 different biomes. These field data are applied to parameterize and evaluate the most broadly used Ep formulations. For each site, we extracted the days for which ecosystems are unstressed based on an energy balance approach and on the anomalies of soil water content. The evaporation measurements during these days were used as reference to calibrate and validate the different methods to estimate Ep.

Our results indicate that a simple radiation-driven formulation calibrated per biome outperforms more complex methods, indicating the dominant effect of radiation variability at ecosystem scales. A slightly more complex Priestley and Taylor method calibrated per biome performed just slightly worse, yet substantially and consistently better than Penman-, Penman-Monteith- or temperature-based approaches. We show that the poor performance of Penman-Monteith formulations relates to the fact that the unstressed stomatal conductance cannot be assumed as constant. Further analysis showed that the biome-specific parameters required for the simple radiation-driven methods are relatively constant per biome, which makes these methods suitable for global models dedicated to explore the impact of global warming on water availability, drought severity or ecosystem productivity.