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Climate controls how ecosystems size the root zone storage capacity at catchment scale

Hongkai Gao (1), Markus Hrachowitz (1), Stan Schymanski (2), Fabrizio Fenicia (3,1), Nutchanart Sriwongsitanon (4), and Hubert Savenije (1)

(1) Delft University of Technology, Civil Engineering and Geosciences, Water Resources Section, Delft, Netherlands (h.gao-1@tudelft.nl), (2) ETH Zurich, Department of Environmental Systems Science, Zurich, Switzerland, (3) EAWAG, Department of System Analysis, Integrated Assessment and Modelling, Dübendorf, Switzerland, (4) Kasetsart University, Department of Water Resources Engineering, Bangkok, Thailand

The root zone moisture storage capacity (S_R) of terrestrial ecosystems is a buffer providing vegetation continuous access to water and a critical factor controlling land-atmospheric moisture exchange, hydrological response and biogeochemical processes. However, it is impossible to observe directly at catchment scale. Here, using data from 300 diverse catchments, it was tested that, treating the root zone as a reservoir, the mass curve technique (MCT), an engineering method for reservoir design, can be used to estimate catchment-scale S_R from effective rainfall and plant transpiration. Supporting the initial hypothesis, it was found that MCT-derived S_R coincided with model-derived estimates. These estimates of parameter S_R can be used to constrain hydrological, climate and land surface models. Further, the study provides evidence that ecosystems dynamically design their root systems to bridge droughts with return periods of 10-40 years, controlled by climate and linked to aridity index, inter-storm duration, seasonality and runoff ratio. This adaptation of ecosystems to climate could be explored for prediction in ungauged basins. We found that implementing the MCT-derived S_R without recalibration has dramatically increased hydrological model transferability.