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Deriving root zone storage capacity from Earth observation

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The root zone storage capacity (S_{R}) is a critical, yet uncertain parameter in hydrological and land surface modelling, ecological and biogeochemical studies, and even investigations on shallow landslide and soil erosion. Unbiased and detailed observations of rooting depth worldwide are not available, but observation-based evaporation and precipitation data with global coverage are increasing in quality. Recently, the Mass Curve Technique (MCT, an engineering method for reservoir design) has been successfully employed to estimate root zone storage capacities at the catchment scale. The method assumes that vegetation adjusts its root zone storage capacity to the smallest required to bridge critical dry periods. Here, we adapt and use MCT with satellite-based evaporation and state-of-the-art precipitation data to derive gridded S_{R} at the global scale. Because ecosystems appear to adapt to drought return periods of 10-40 years, the S_{R} are normalized using Gumbel distribution with accompanying sensitivity analyses. Upon implementing the estimated S_{R} in a global hydrological model, we find that the S_{R} correctly allow for simulated dry-season evaporation in contrast to the simulation results achieved using look-up table rooting depths. Correlating S_{R} with climate indices further reveal different ecosystem strategies to cope with drought. Comparing the estimated S_{R} to previous estimates of global rooting depth shows that our S_{R} estimate is realistic and can correct for bias in regions where root depth field data are scarce. In contrast to earlier attempts to quantify root zone storage capacity, this method does not require soil or vegetation information, is model independent, and makes few assumptions. This study presents an "observation-based" root zone storage capacity at the global scale, directly implementable in hydrological and land surface models. The dataset can potentially remediate current parameterization biases in land surface models and in particular improve dry season simulations. In addition, the simple method can easily be used at regional scales using other satellite-based evaporation input datasets where such are of better quality than the available global data.