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Using a data-conditioned stochastic parameterization to evaluate the role of plant trait plasticity in controlling water and carbon budgets

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Observed plant trait plasticity indicates that the current modeling paradigm of specifying fixed parameters based on plant functional type (PFT) may potentially bias simulations of carbon and water dynamics. However, despite growing global trait databases, measurements remain too sparse in space and time to be able to directly incorporate trait plasticity into ecohydrologic models. This stymies our ability to assess how trait plasticity may impact carbon and water budgets. Thus, how to appropriately represent plant parameter variability in models to capture trait plasticity is a research priority. Here we present a data-conditioned stochastic parameterization of trait variability; through data assimilation, we utilize sparse global trait observations from the TRY database as prior information, which we then probabilistically correct and augment using satellite and in situ measurements over time. This approach produces data-constrained estimates of continuous, time-varying plant traits that can be used to evaluate plant plasticity and its relationship with other environmental variables. We test this framework with the Community Land Model 4.5 (CLM 4.5), which we implement for a desert shrubland watershed in the Mojave Desert, where desert plants are known to acclimate to highly variable weather conditions. With the data-conditioned stochastic parameterization of plant traits, we test the hypothesis that in water-limited ecosystems, multi-decadal trait plasticity not only occurs in response to hydroclimatic and soil conditions, but it further feeds back to control carbon and water budgets. We propose that a stochastic parameterization of trait plasticity can provide a robust and effective way for projecting future carbon and water cycling under changing environmental conditions.