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Precipitation mediates transpiration sensitivity to evaporative demand in the neotropics

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Tree transpiration in humid tropical forests modulates the global water cycle and is a key driver of climate regulation. Yet, our understanding and predictions of how tropical trees regulate water use in response to climate variability remain elusive. With a progressively warming climate, atmospheric evaporative demand (i.e. vapor pressure deficit, VPD) will be increasingly important for plant functioning, becoming the major control of plant water use in the 21st century. Using measurements in 34 tree species at seven sites across a precipitation gradient in the neotropics, we determined how the VPD threshold at which sap flux levels-off at maximum values (VPD-FD) and maximum sap flux (FDmax) vary with precipitation regime (long-term annual precipitation, MAP; seasonal drought intensity, P-DRY) and two functional traits related to foliar and wood economics spectra (leaf mass per area, LMA; wood specific gravity, WSG). We show that, even though VPD-FD and FDmax are highly variable within sites, they follow a negative trend in response to increasing MAP and P-DRY across sites. LMA and WSG exerted little detectable effects on VPD-FD and FDmax, suggesting that these widely-used integrative traits provide limited explanatory power of dynamic plant responses to environmental variation within hyper-diverse tropical forests. This study demonstrates that long-term precipitation and thus, soil moisture, play a critical role in the transpiration response of humid tropical forests to VPD. Moreover, our findings suggest that under predicted higher evaporative demand, trees growing in wetter environments in humid tropical regions may be subjected to reduced water exchange with the atmosphere relative to trees growing in drier climates.