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Water stress induced breakdown of carbon-water relations: indicators from diurnal FLUXNET patterns

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Understanding of terrestrial carbon and water cycles is currently hampered by an uncertainty in how to capture the large variety of plant responses to drought across climates, ecological strategies, and environments. In FLUXNET, many sites do not uniformly report the ancillary variables needed to study drought response physiology such as soil moisture, sap flux, or species composition. In this sense, the use of diurnal patters to derive clues on ecosystem water limitation responses at a daily resolution from an existing dataset could prove valuable, if nothing less than a benchmark to test current hypotheses. To this end, we propose two data-driven indicators derived directly from the eddy covariance data and based on expected physiological responses to hydraulic and non-stomatal limitations. Hydraulic limitations are proxied using the normalized diurnal centroid, which measures the degree to which the flux of ET is shifted toward the morning. Non-stomatal limitations are characterized by the Diurnal Water:Carbon Index (DWCI), which measures the degree of coupling between daily ET and GPP fluxes. Globally, we found significantly high frequencies of morning shifted days in dry/Mediterranean climates and savanna plant functional types (PFT), whereas high frequencies of decoupling were found in dry climates and grassland/savanna PFTs. Overall, both the diurnal centroid and DWCI were associated with high net radiation and low latent energy. Using three water use efficiency (WUE) models, we found the mean difference between expected and observed WUE to be 0.09 to -0.23 umol/mmol and -0.42 to -0.49 umol/mmol for decoupled and morning shifted days respectively, indicating an increase in WUE associated with the metrics that the models were unable to capture. Furthermore we discuss the application of diurnal centroid and DWCI to methods of evapotranspiration partitioning and estimation of ecosystem isohydricity.