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Water use traits derived from a global database of sap flow measurements (SAPFLUXNET)

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Transpiration regulation by plants is a key (and still not completely understood) process that underlies the variation in vegetation drought responses and land evaporative fluxes. Regional syntheses of the biotic and environmental influences on ecosystem-level evapotranspiration have shown a predominant role of atmospheric demand in controlling evaporative fluxes. However, data syntheses based on ecosystem evapotranspiration cannot address the variation in drought responses at the individual level modulated by changes in phenology, tree size or competition. Whole-plant water use traits can be extracted from continuous measurements of sap flow in plant stems by relating them to environmental drivers. The variation of these water use traits can then be related to multiple plant- and stand-level attributes. The SAPFLUXNET database has already compiled data for > 40 species, from globally distributed sites, and the number of contributed data sets is increasing rapidly. Here we test different methods to retrieve quantities related to (i) maximum sap flow rates and (ii) sap flow sensitivity to vapour pressure deficit (VPD). We use a direct estimation of maxima using the upper quantiles (e.g. 95%) for the distribution of sap flow values for a given plant and season. We also test a model-based approach relating sap flow to VPD by fitting a saturating exponential function using nonlinear quantile regression for the upper quantiles. This latter approach also provides an estimate of the sap flow sensitivity to VPD. Apart from fitting the sap flow-VPD relationship pooling all data from a growing season, we also perform the analysis using a 5-day moving window, to capture the seasonal variation in water use traits and to relate this variation to soil moisture, when available. We then examine the variation in both parameters as related to species, climate and plant- and stand-level attributes and show how these water use traits are related to other plant functional traits.