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Biophysical controls on evapotranspiration and water use efficiency in natural, semi-natural and managed African ecosystems

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The effects of climatic factors and vegetation type on evapotranspiration (E) and water use efficiency (WUE) were analyzed using tower-based eddy-covariance (EC) data of eleven African sites (22 site years) located across a continental-scale transect. The seasonal pattern of E was closely linked to growing-season length and rainfall distribution. Although annual precipitation (P) was highly variable among sites (290 to 1650 mm), minimum annual E was not less than 250 mm and reached a maximum of 900 mm where annual P exceeded 1200 mm. Site-specific interannual variability in E could be explained by either changes in total P or variations in solar irradiance. At some sites, a highly positive linear correlation was found between monthly sums of E and net radiation (R_n), whereas a hysteretic relationship at other sites indicated that E lagged behind the typical seasonal progression of R_n. Results of a cross-correlation analysis between daily (24-h) E and R_n revealed that site-specific lag times were between 0 days and up to a few weeks depending on the lag of vapor pressure deficit (D) behind R_n and vegetation type. Physiological parameters (e.g. mean dry-foliage Priestley–Taylor alpha) implied that stomatal limitation to transpiration prevailed. During the rainy season, a strong linear correlation between monthly mean values of gross primary production (GPP) and E resulted in water use efficiency being constant with lower values at grass-dominated sites (~2 to ~3.5 g C kg⁻¹ H₂O) than at natural woodland sites and plantations (~4.5 to ~6 g C kg⁻¹ H₂O).