Unraveling ET Components with Above/Subcanopy Eddy Covariance Systems and Independent Lysimeter and Sapflow Estimates in a Mediterranean Savannah

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Mediterranean savannah ecosystems are typically characterized by a sparse oak-tree stand and its underlying pasture, which provide invaluable social and ecological benefits. Due to changes in climate, the sustainability of such ecosystems is being threatened by droughts and separating evapotraspiration (ET) into component processes is crucial to better understand how grass and trees rival each other in water use. However, separating total ET into grass and trees is challenging due to the fact that classical eddy covariance 1) directly only measures total ET and 2) biases in the respective energy balance are often observed. Consequently, most clumping models derived from the surface energy balance equation (e.g. Penman-Monteith) may fail in describing evaporating surfaces. Here, we address these challenges in a Mediterranean savannah tree-grass ecosystem, by synchronous, combined measurements via classical eddy covariance EC), sub-canopy EC, sap-flow, and replicated lysimeters.

Our results revealed that grass dominated annual evaporative loss from 69 to 87% depending upon the spectral correction method applied. The comparison between latent heat fluxes (LE) measured by the subcanopy EC and independent LE by lysimeters showed that EC had a tendency to underestimate LE under certain environmental conditions (up to 35% of annual values). Interestingly, a diagnostic evaluation of the errors with a random forest model showed that differences followed quite structured patterns and were associated with certain atmospheric conditions: turbulent mixing deficiencies and or stable atmospheric stratification, high relative humidity. Nevertheless, those differences were remarkably lower when likening above EC versus $LE_{upscaled}$ (14%). Our results revealed that the degree of EBC is highly sensitive to the flux correction method applied (slopes ranged from 0.92 to 1.07). Consistent with the EBC, independent LE estimates matched well with LE_{Bowen} and the EBC gap decreased when $LE_{upscaled}$ was used (slope 0.96). The use of independent estimates of LE together with machine learning methods are proposed as a powerful means to diagnose the complexity behind LE errors and give

insights into the energy imbalance problem. Finally, an evaluation of available ET partitioning methods and models will be further discussed.