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Impact of water use efficiency on eddy covariance flux partitioning using correlation structure analysis

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Partitioned land surfaces fluxes (e.g. evaporation, transpiration, photosynthesis, and ecosystem respiration) are needed as input, calibration, and validation data for numerous hydrological and land surface models. However, one of the most commonly used techniques for measuring land surface fluxes, Eddy Covariance (EC), can directly measure net, combined water and carbon fluxes (evapotranspiration and net ecosystem exchange/productivity). Analysis of the correlation structure of high frequency EC time series (hereafter flux partitioning or FP) has been proposed to directly partition net EC fluxes into their constituent components using leaf-level water use efficiency (WUE) data to separate stomatal and non-stomatal transport processes. FP has significant logistical and spatial representativeness advantages over other partitioning approaches (e.g. isotopic fluxes, sap flow, microlysimeters), but the performance of the FP algorithm is reliant on the accuracy of the intercellular CO_2 (ci) concentration used to parameterize WUE for each flux averaging interval. In this study, we tested several parameterizations for ci as a function of atmospheric CO_2 (ca), including (1) a constant ci/ca ratio for C3 and C4 photosynthetic pathway plants, (2) species-specific ci/ca-Vapor Pressure Deficit (VPD) relationships (quadratic and linear), and (3) generalized C3 and C4 photosynthetic pathway ci/ca-VPD relationships. We tested these ci parameterizations at three agricultural EC towers from 2011-present in C4 and C3 crops (sugarcane – Saccharum officinarum L. and peach – Prunus persica), and validated again sap-flow sensors installed at the peach site. The peach results show that the species-specific parameterizations driven FP algorithm came to convergence significantly more frequently ($\sim$20% more frequently) than the constant ci/ca ratio or generic C3-VPD relationship. The FP algorithm parameterizations with a generic VPD relationship also had slightly higher transpiration (5 Wm-2 difference) than the constant ci/ca ratio. However, photosynthesis and respiration fluxes over sugarcane were $\sim$15% lower with a VPD-ci/ca relationship than a constant ci/ca ratio. The results illustrate the importance of combining leaf-level physiological observations with EC to improve the performance of the FP algorithm.