Reconciling Evapotranspiration Partitioning Models with Evidence of Anomalously Low Isotopic Fractionation during Evaporation in Semi-arid Landscapes

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Partitioning land surface latent heat flux into evaporation (E) and transpiration (T) remains challenging despite a basic understanding of the underlying mechanisms. Water isotopologues are useful tracers for separating evaporation and transpiration contributions because E and T have distinct isotopic ratios. Here the isotope-based partitioning method is used at a semi-arid grassland tall-tower site in Colorado. Results suggest that under certain conditions evaporation cannot be isotopically distinguished from transpiration without modifying existing partitioning techniques. Over a 4-year period, profiles of stable oxygen and hydrogen isotope ratios of water vapor were measured from the surface to 300 m and soil water down to 1 m along with standard meteorological fluxes. Using these data, it was found that rainfall, equilibration, surface water vapor exchange, and sub-surface vapor diffusion all contribute to the isotopic composition of evapotranspiration (ET). Applying the standard isotopic approach to find the transpiration portion of ET (i.e., T/ET), a significant discrepancy is found compared with a method to constrain T/ET based on gross primary productivity (GPP). By evaluating kinetic effects associated with soil evaporation and vapor diffusion, a significant proportion (58-84%) of evaporation following precipitation is found to be non-fractionating. This is possible when water from discrete soil layers is nearly completely evaporated as soil dries. The isotope ratio of non-fractionating evaporative flux is indistinguishable from the isotope ratio of transpiration, and may therefore explain the overestimation of T/ET from traditional "two-stream" partitioning methods. Accounting for weaker fractionation during evaporation reconciles isotope-based partitioning T/ET estimates with the GPP method.

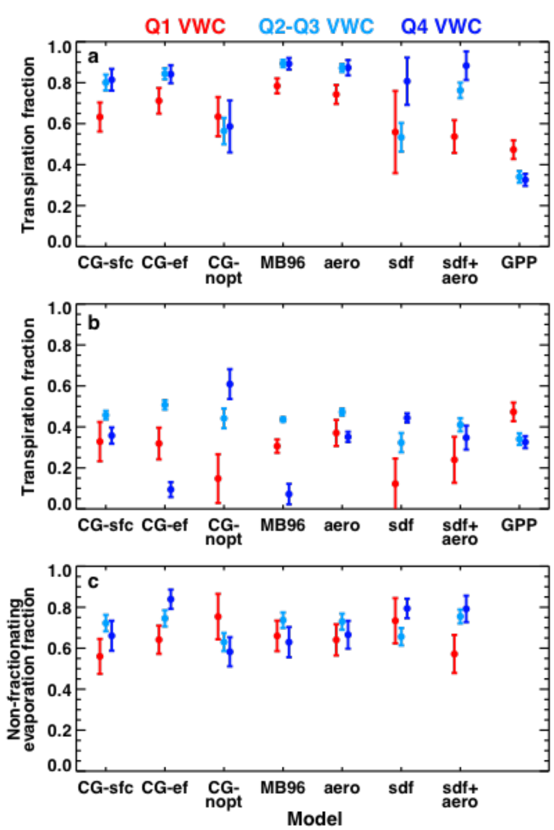

Figure 1. (a) Transpiration fraction calculated for seven different model tests for lowest quartile (Q1), intermediate quartiles (Q2-Q3) and highest quartile (Q4) of total volumetric water content in the top 15 cm of the soil column, compared to GPP method, **(b)** Transpiration fraction for same seven model tests including a non-fractionating evaporation component, **(c)** Non-fractionating evaporation fraction. Note that the fractionating evaporation fraction (not plotted here) is simply 1 minus the non-fractionating evaporation fraction plotted in (c). The GPP method predicts a transpiration fraction of 0.38 ± 0.08, while the average of all models shown here is 0.67 ± 0.08 for (a) and 0.43 ± 0.03 for (b) where non-fractionating evaporation is included in the calculation. Non-fractionating evaporation in (c) makes up 58-84 % of the total evaporation under wet (Q4) conditions, and 56-75 % of the total evaporation under dry (Q1) conditions.