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The inconvenient truth about eddy covariance flux partitioning and implications for global carbon cycle estimates

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Ecosystem respiration (ER) and gross primary productivity (GPP) are key carbon cycle concepts. Global estimates of ER and GPP are largely based on measurements of the net ecosystem CO_2 exchange by means of the eddy covariance method from which ER and GPP are inferred using so-called flux partitioning algorithms.
Using a simple two-source model of ecosystem respiration, consisting of an above-ground respiration source driven by simulated air temperature and a below-ground respiration source driven by simulated soil temperature, we demonstrate that the two most popular flux partitioning algorithms are unable to provide unbiased estimates of daytime ER (ignoring any reduction of leaf mitochondrial respiration) and thus GPP. The bias is demonstrated to be either positive or negative and to depend in a complex fashion on the driving temperature, the ratio of above- to below-ground respiration, the respective temperature sensitivities, the soil depth where the below-ground respiration source originates from (and thus phase and amplitude of soil vs. surface temperature) and day length.
The insights from the modeling analysis are subject to a reality check using direct measurements of ER at a grassland where measurements of ER were conducted both during night and day using automated opaque chambers. Consistent with the modeling analysis we find that using air temperature to extrapolate from nighttime to daytime conditions overestimates daytime ER (by 20% or ca. 65 gC m-2 over a 100 day study period), while soil temperature results in an underestimation (by 4% or 12 gC m-2).
We conclude with practical recommendations for eddy covariance flux partitioning in the context of the FLUXNET project.