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New Insights on Canopy Photosynthesis from novel Isotopic Flux Partitioning in a temperate forest

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Standard approaches for partitioning net eddy fluxes of CO_2 into gross primary production (GPP) and ecosystem respiration (R) typically work by extrapolating R from night to day using an empirical function fit to a week or a month of data. Such methods assume that daytime R behaves like nighttime R, and is either constant or a smoothly varying function of temperature. Isotopic partitioning is an alternative that involves no assumptions about the behavior of R or GPP (though it requires knowledge or assumptions about the isotopic fractionations occurring in and around the leaves) and which allows for the investigation of diel variations because each flux measurement is partitioned separately.

A novel isotopic flux partitioning approach using the first long-term isotopic CO_2 eddy flux record (measured at Harvard Forest) reveals differences in both the diel and the seasonally averaged behavior of GPP as compared to conventional partitioning. At the diel timescale, large ($\sim$10 umol m-2 s-1), rapid ($\sim$2 hours) variations in the respiratory component of measured NEE associated with subtle changes in wind direction are misattributed to GPP by conventional partitioning, leading to inconsistency in the response of GPP to photosynthetically active radiation (PAR). Isotopically partitioned GPP responds more consistently to PAR, and the seasonally averaged light response curve of isotopically partitioned GPP is more linear than that of conventionally partitioned GPP, suggesting that unsaturated (steeply inclined) leaves perform most of the canopy photosynthesis. Isotopic partitioning further suggests that conventional partitioning based on the temperature-dependent extrapolation of nighttime R overestimates GPP by 10–20%, on average, consistent with its neglect of the suppression of foliar dark respiration by sunlight. Isotopic partitioning is thus changing our interpretation of ecosystem CO_2 exchange at the Harvard Forest.