Geophysical Research Abstracts,
Vol. 11, EGU2009-2074, 2009
EGU General Assembly 2009

Estimating nocturnal ecosystem respiration from the vertical turbulent flux and change in storage of carbon dioxide.

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Micrometeorological measurements of night time ecosystem respiration can be systematically biased when stable atmospheric conditions lead to drainage flows associated with decoupling of air flow above and within plant canopies. The associated horizontal and vertical advective fluxes cannot be measured using instrumentation on the single towers typically used at micrometeorological sites. A common approach to minimize bias is to use a threshold in friction velocity, u_*, to exclude periods when advection is assumed to be important, but this is problematic in situations when in canopy flows are decoupled from the flow above. Using data from 25 flux stations in a wide variety of forest ecosystems globally, we examine the generality of a novel approach to estimating nocturnal respiration developed by van Gorsel et al. (2007, Tellus, 59B, 307-403). The approach is based on the assumption that advection is small relative to the vertical turbulent flux (F_c) and change in storage (F_s) of CO_2 in the few hours after sundown. The sum of F_c and F_s reach a maximum during this period which is used to derive a temperature response function for ecosystem respiration. Measured hourly soil temperatures are then used with this function to estimate respiration R_{Rmax}. The new approach yielded excellent agreement with (1) independent measurements using respiration chambers, (2) with estimates using ecosystem light-response curves of $F_c + F_s$ extrapolated to zero light, R_{LRC}, and (3) with a detailed process-based forest ecosystem model, R_{cast}. At most sites respiration rates estimated using the u_*-filter, R_{ust}, were smaller than R_{Rmax} and R_{LRC}. Agreement of our approach with independent measurements indicates that R_{Rmax} provides an excellent estimate of night time ecosystem respiration.