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A night-and-day difference: Why diel patterns of soil CO₂ efflux vary across forests

July 24, 2026



Undergraduate research assistant Kean Mansour manages an automated soil respiration chamber in a Pennsylvania forest. Photo courtesy of Timmy Stehmen.

Soil CO₂ efflux is among the largest and most uncertain fluxes in the global carbon (C) cycle. One source of uncertainty is the diel pattern—recurring changes over 24 hours. Previous studies suggest that diel changes are small and that measuring soil CO₂ efflux from 9:00 a.m. to noon sufficiently captures the daily mean. Yet, it is unclear how well this assumption works across diverse forests or across gradients within a forested catchment. To fill this knowledge gap, researchers from Penn State University analyzed a new, open-access database of millions of hourly soil respiration measurements ([COSORE](#)). Across 31 globally distributed forests, diel soil CO₂ efflux varied widely in timing and magnitude, suggesting that there is no “one size fits all” approach for selecting sampling times.

The authors intensively studied one Pennsylvania forest to tease out mechanisms controlling these diel patterns. At this site, soil CO₂ efflux peaked at night, contrary to expectations. Amplitude was highest at locations times with high biological activity, and the timing of peak soil CO₂ efflux lagged peak surface soil temperature by three to five hours, suggesting that diel variation across disparate forests may be predictably identified by timing when warm soil temperatures intersect soil depths with high C stocks or root densities. Increasing predictability of diel soil CO₂ efflux patterns will improve measurement and simulation of the forest C cycles, which in turn, are scaled up to better understand the global C cycle.

Dig deeper

Kopp, M. W., Davis, K. J., Duncan, J. M., & Kaye, J. P. (2026). Diel patterns of soil CO₂ efflux vary among and within forests. *Soil Science Society of America Journal*, 90, e70241. <https://doi.org/10.1002/saj2.70241>

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