Overestimation of closed-chamber soil CO2 effluxes at low atmospheric turbulence

Soil respiration (R-s) is an important component of ecosystem carbon balance, and accurate quantification of the diurnal and seasonal variation of R-s is crucial for a correct interpretation of the response of R-s to biotic and abiotic factors, as well as for estimating annual soil CO2 efflux rates. In this study, we measured R-s hourly for 1 year by automated closed chambers in a temperate Danish beech forest. The data showed a clear diurnal pattern of R-s across all seasons with higher rates during night-time than during daytime. However, further analysis showed a clear negative relationship between flux rates and friction velocity (u*) above the canopy, suggesting that R-s was overestimated at low atmospheric turbulence throughout the year due to non-steady-state conditions during measurements. Filtering out data at low u* values removed or even inverted the observed diurnal pattern, such that the highest effluxes were now observed during daytime, and also led to a substantial decrease in the estimated annual soil CO2 efflux. By installing fans to produce continuous turbulent mixing of air around the soil chambers, we tested the hypothesis that overestimation of soil CO2 effluxes during low u* can be eliminated if proper mixing of air is ensured, and indeed the use of fans removed the overestimation of R-s rates during low u*. Artificial turbulent air mixing may thus provide a method to overcome the problems of using closed-chamber gas-exchange measurement techniques during naturally occurring low atmospheric turbulence conditions. Other possible effects from using fans during soil CO2 efflux measurements are discussed. In conclusion, periods with low atmospheric turbulence may provide a significant source of error in R-s rates estimated by the use of closed-chamber techniques and erroneous data must be filtered out to obtain unbiased diurnal patterns, accurate relationships to biotic and abiotic factors, and before estimating R-s fluxes over longer timescales.

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