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Overestimation of soil CO_2 fluxes from closed chamber measurements at low atmospheric turbulence biases the diurnal pattern and the annual soil respiration budget

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Precise quantification of the diurnal and seasonal variation of soil respiration (R_s) is crucial to correctly estimate annual soil carbon fluxes as well as to correctly interpret the response of R_s to biotic and abiotic factors on different time scale.

In this study we found a systematic effect of low atmospheric turbulence on continuous hourly R_s measurements with closed chambers throughout one year in a temperate Danish beech forest. Using friction velocity ($u_\star$) measured at the site above the canopy, we filtered out chamber flux data measured at low atmospheric turbulence.

The non-filtered data showed a clear diurnal pattern of R_s across all seasons with highest fluxes during night time suggesting an implausible negative temperature sensitivity of R_s. When filtering out data at low turbulence, the annually averaged diurnal pattern changed, such that the highest R_s fluxes were seen during day time, i.e. following the course of soil temperatures. This effect on the diurnal pattern was due to low turbulence primarily occurring during night time. We calculated different annual R_s budgets by filtering out fluxes for different levels of $u_\star$. The highest annual R_s budget was found when including all data and it decreased with an increasing $u_\star$ filter threshold. Our results show that R_s was overestimated at low atmospheric turbulence throughout the year and that this overestimation considerably biased the diurnal pattern of R_s and led to an overestimation of the annual R_s budget. Thus we recommend that that any analysis of the diurnal pattern of R_s must consider overestimation of R_s at low atmospheric turbulence, to yield unbiased diurnal patterns. This is crucial when investigating temperature responses and potential links between CO_2 production and R_s on a short time scale, but also for correct estimation of annual R_s budgets.

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