Observing $^{13}$C labelling kinetics in CO$_2$ respired by a temperate grassland ecosystem

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The kinetic characteristics of the main sources of ecosystem respiration are quite unknown, partly due to methodological constraints. We present a new open-top chamber (OTC) apparatus for continuous $^{13}$C/$^{12}$C labelling and measurement of ecosystem CO$_2$ fluxes. It includes four dynamic flow-through OTCs, a unit mixing CO$_2$-free air with $^{13}$C-depleted CO$_2$, and a CO$_2$ analyser and an online isotope ratio mass spectrometer. Two different methods were applied for observation of the tracer during nighttime respiration in the field: open dynamic and closed static chamber mode.

The concentration ($367\pm6.5$ μmol mol$^{-1}$) and δ$^{13}$C ($-46.9\pm0.4\%$) of CO$_2$ in the OTCs was stable during photosynthesis due to high air throughflux and minimal incursion through the buffered vent. Soil CO$_2$ efflux was not affected by pressure effects during respiration measurements. The labelling kinetics of respiratory CO$_2$ measured in the open dynamic mode in the field agreed with that of excised soil+vegetation blocks measured in a laboratory-based reference system. The kinetics fitted a two-source system, with a rapidly labelled source ($T_{1/2}$ 2.6 d) supplying 48% of respiration, and the other source (52%) releasing no tracer during 14 days of labelling. Measurements in the closed static mode resulted in a significantly larger fraction of observed tracer. This bias was largely explained by non-steady-state diffusion effects of labelling CO$_2$ stored in the soil gas and water pores during the preceding labelling period.