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A multi-layer, closed-loop system for continuous measurement of CO_2 concentrations and its isotopic signature in forest soils as a basis for CO_2 efflux calculation and for revealing its controls

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We present a setup of measurement devices that allows the application of the soil CO_2 gradient approach for CO_2 efflux calculation in combination with the analysis of isotopic signature (δ13C). Vertical profiles of CO_2 concentrations in air-filled pores of soil were measured using miniature NDIR sensors within a 16-channel closed-loop system where equilibrium with soil air can be achieved using hydrophobic, gas-permeable porous polypropylene tubes circulating gas using peristaltic pumps. A 16-position multiplexer allows the connection to an isotopic CO_2 analyser.

This setup was applied at two ICP Forest intensive monitoring sites, a beech and a pine forest on sandy soils located in Brandenburg, Germany. CO_2 concentrations in air-filled pores of soils were measured on top of soil surface, below the humus layer, and in 10cm, 20cm, 30cm and 100 cm depths every 30 min. At both sites, soil moisture and temperature were measured continuously in the respective soil depths in identical time intervals. Isotopic signatures of soil CO_2 was detected by measurement campaigns.

After two years of measurements, our results provided evidence for distinct seasonal dynamics and vertical gradients of soil CO_2 concentration and δ13C values. Varying impacts of soil temperature and moisture on CO_2 concentration were revealed, highlighting its impact on soil physical and soil biological controls. Higher levels of CO_2 concentration and a more distinct seasonal dynamics were detected at the beech site compared to the pine site.

The collected data provide a suitable database for calculation of CO_2 efflux and modelling of soil respiration.