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Measuring and modelling the intra-day variability of the $^{13}CO_2$ & $^{12}CO_2$ vertical soil profile production in a Scots pine forest

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Vertical profile of CO_2 production (Ps) and transport, as well as their isotopic discrimination ($^{13}CO_2/^{12}CO_2$) should be considered to improve the soil CO_2 efflux (Fs) mechanistic understanding and especially its short-term temporal variations. In this context, we propose a new methodology able to measure continuously and simultaneously Fs, the vertical soil CO_2 concentration ($[CO_2]$) profile and their respective isotopic signature (δFs and δCO_2) [1]. The Ps of the different soil layers and their isotopic signature (δPs) can then be determined from these measurements by an approach considering diffusion as the only gas transport. A field campaign was conducted with this device at the Scots Pine Hartheim forest (Germany). The results [2] show (i) a Ps dependence on local temperature specific for each layer, (ii) an enrichment of δPs with soil drought, (iii) Fs and $[CO_2]$ large intra-day fluctuations non explained by the soil temperature and moisture. These fluctuations can be generated by other processes creating Ps and/or transport variability. To investigate about the nature of these processes, some sensitivity analyses have been performed with a soil CO_2 model simulating both production and transport. The impacts of the introduction of advection, dispersion and phloem pressure concentration wave (through dependence of Ps on vapour pressure deficit) on intra-day Fs and $[CO_2]$ variations have been quantified. We conclude that these variations are significantly better represented when the phloem pressure wave expression is included in the simulations. The study of the processes related to CO_2 production seems to be a better option than an investigation about transport to explain the intra-day Fs variability.