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Localizing CO_2 (and other gas) sources in the soil: Measuring and modeling 3D soil gas transport

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Our world is not a disk, and soil is not 1D but 3D. Yet, most studies reduce soils to "representative" simplified 1D profiles with a dominating vertical gradient of soil physical and chemical properties. In many cases, this is a useful and fair representation of the realty. Yet, in some cases, lateral processes have to be considered to avoid misinterpretation of experimental results e.g. in trenching experiments or to assess the contribution of oriented structures like root networks of trees. The objective was to develop a method that allows for monitoring the 3D gas transport in soils, including 3D localization of gas sources within a soil profile. To develop a new method laboratory tests under controlled conditions were run in large barrels filled with sand, allowing for the evaluation of the method and a reliable sensitivity analysis. To determine the 3D patterns of the soil gas diffusion coefficient DS/D0 in situ, inert tracer gases were injected into the soil and the resulting concentration distribution was sampled using multi-level gas samplers. Three tracer gases were used simultaneously. They were injected at the lower end of the 3 gas samplers that were used to measure the gas concentration distributions. In a second step, soil gas transport was modelled inversely 3D using the Finite Element Modeling program COMSOL. Different scenarios were tested in the barrel as controlled experiments to evaluate the method. A defined volume of sand was replaced by (1) foam and (2) gravel, and 3 D DS/D0 patterns were modeled, respectively. Concurrently, CO_2 as example of a target gas was injected as a point source, and the location of the CO_2 source was modelled inversely. This method will allow eventually monitoring the effect of plants growing roots into the surrounding soil or ants' nests or moving cockchafer larvae in the soil, which also modify the spatial patterns of soil aeration and soil respiration.

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