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A novel in-situ method for real-time monitoring of gas transport in soil

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Gas exchange between soil and atmosphere is important for the biogeochemistry of soils. Gas transport in soil is commonly assumed to be governed by molecular diffusion and is usually described by the soil gas diffusion coefficient D_S characterizing the ability of the soil to "transport passively" gas through the soil. One way to determine D_S is sampling soil cores in the field and measuring D_S in the lab. Unfortunately this method is destructive and laborious. Moreover, a few previous field studies identified other gas transport processes in soil to significantly enhance the diffusive gas transport. However, until now, no method is available to measure gas transport in situ in the soil.

We developed a novel method to monitor gas transport in soil in situ. The method includes a custom made gas sampling device, the continuous injection of an inert tracer gas and inverse gas transport modelling in the soil. The gas sampling device has several sampling depths and can be easily installed into a vertical hole drilled by an auger, which allows for fast installation of the system. Helium (He) as inert tracer gas was injected continuously at the lower end of the device. The resulting steady state distribution of He was used to deduce the depth profile of D_S. Gas transport in the soil surrounding the gas-sampling-device/soil system was modeled using the Finite Element Modeling program COMSOL .

We tested our new method both in the lab and during two short field studies and compared the results with a reference method using soil cores. D_S profiles obtained by our in-situ method were consistent with D_S profiles determined based on soil core analyses. During a longer monitoring field campaign, typical soil-moisture effects upon gas diffusivity such as an increase during a drying period or a decrease after rain could be observed consistently. Under windy conditions we additionally measured for the first time the direct enhancement of gas transport in soil due to wind-induced pressure-pumping which could increase the effective D_S up to 30% in the topsoil.

Our novel monitoring method can be quickly and easily installed and allows for monitoring continuously soil gas transport over a long time. It allows monitoring physical modifications of soil gas diffusivity due to rain events or evaporation but it also allows studying non-diffusive gas transport processes in the soil.