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Influence of wind-induced air pressure fluctuations on topsoil gas concentrations within a Scots pine forest

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Commonly it is assumed that soil gas transport is dominated by molecular diffusion. Few recent studies indicate that the atmosphere above the soil triggers non-diffusive gas transport processes in the soil, which can enhance soil gas transport and therefore soil gas efflux significantly. During high wind speed conditions, the so called pressure pumping effect has been observed: the enhancement of soil gas transport through dynamic changes in the air pressure field above the soil. However, the amplitudes and frequencies of the air pressure fluctuations responsible for pressure pumping are still uncertain. Moreover, an *in situ* observation of the pressure pumping effect is still missing.

To investigate the pressure pumping effect, airflow measurements above and below the canopy of a Scots pine forest and high-precision relative air pressure measurements were conducted in the below-canopy space and in the soil over a measurement period of 16 weeks. To monitor the soil gas transport, a newly developed gas measurement system was used. The gas measurement system continuously injects helium as a tracer gas into the soil until a diffusive steady state is reached. With the steady state concentration profile of the tracer gas, it is possible to inversely model the gas diffusion coefficient profile of the soil. If the gas diffusion coefficient profile differed from steady state, we deduced that the soil gas transport is not only diffusive, but also influenced by non-diffusive processes.

Results show that the occurrence of small air pressure fluctuations is strongly dependent on the mean above-canopy wind speed. The wind-induced air pressure fluctuations have mean amplitudes up to 10 Pa and lie in the frequency range 0.01-0.1 Hz. To describe the pumping motion of the air pressure field, the pressure pumping coefficient (PPC) was defined as the mean change in pressure per second. The PPC shows a clear quadratic dependence on mean above-canopy wind speed. Empirical modelling of the measured topsoil helium concentration demonstrated that the PPC is the most important predictor for changes in the topsoil helium concentration.

Comparison of time periods with high PPC and periods of low PPC showed that the soil gas diffusion coefficient in depths between 5-10 cm increased up to 30% during periods of high PPC compared to steady state. Thus, the air pressure fluctuations observed in the atmosphere and described by the PPC penetrate into the soil and influence the topsoil gas transport.