Geophysical Research Abstracts
Vol. 19, EGU2017-5494, 2017
EGU General Assembly 2017

Gas transport in highly permeable, dry porous media

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Gas exchange between soil and atmosphere is far more efficient via advective than diffusive mechanisms. Whereas advection requires media permeability be sufficiently high and an advecting driving mechanism, diffusion transport occurs in all permeabilities. Traditionally, diffusion models generally have focused only on low permeability media (sand particles and smaller, $k < \sim 10\text{-}5$ cm2). Here we establish the validity of these models to quantify diffusive transport in higher permeability media when climatic conditions do not favor advection. A permeability cutoff is quantified, such that above it traditional diffusion models become inaccurate. Results are based on experiments using large columns filled with different homogeneous spherical particles, conducted inside a climate-controlled laboratory especially designed for quantifying soil-gas diffusivity under isothermal and windless conditions. The results indicate that traditional diffusion models are accurate for permeability values below $2.7\times 10\text{-}3$ cm2. Above this threshold, gas transport could not be explained by diffusion alone. Our measurements indicate that for permeability values above this threshold gas flux is higher than can be explained by diffusion, even under stable environmental conditions where advection is not expected. The findings of this research can contribute to better understanding of gas transport in high-permeability porous media such as: aggregated soils, snowpacks and mines stockpiles.