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The effect of thermal convection on CO_2 emission from soil aggregates

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Earth-atmosphere CO_2 gas exchange from high permeability soils can be significantly affected by non-diffusive transport mechanisms. In this work we studied CO_2 soil-atmosphere gas exchange under both day-time and night-time conditions, focusing on the impact of thermal convection during the night. Experiments were performed in a climate-controlled laboratory.

One-meter long columns were packed with matrix of different grain size (sand, soil aggregates and empty column as control). Air with 2000 ppm CO_2 was injected into the bottom of the columns and CO_2 concentrations within the columns were continuously monitored by gas analyzers. Two scenarios were compared for each column: (1) diffusive transport by imposing isothermal conditions, representing daytime conditions; and (2) convective transport by imposing a vertical thermal gradient, i.e. atmosphere colder than the soil, representing nighttime conditions. The experiments results show that under isothermal conditions, diffusion is the major mechanism for surface-atmosphere gas exchange and not sensitive to grain size, while, under nighttime conditions the prevailing mechanism depends on the air permeability of the matrix and is thus sensitive to grain size. Under the conditions of the investigated experimental setup, sand sized grains suppressed convection, while soil aggregates permitted convective transport of CO_2 leading to a CO_2 flux rate that was two orders of magnitude higher than the diffusive flux.

The results of this work suggests that thermal convective venting enhance CO_2 flux from high permeability surfaces, which, at the local scale contributes to soil aeration, and at larger scales can also affects the global CO_2 cycle.