# Influence of the Atmospheric Disturbance on the Respiration of a Forest Soil

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## Abstract

Introduction:
The assessment of forest soil respiration and its isotopic composition is one of the important issues for the carbon cycling modeling (in the framework of greenhouse gas emission control) because it is often inaccurate. Indeed, the soil respiration is a complex process, depending on the coupling of several phenomena, which is therefore highly sensitive to any disturbance. A measurement campaign has been realized at the permanent forest experimental site of Hartheim (Germany). Two measured parameters are the time evolution of the global $CO_2$ flux leaving the soil $F_{CO2}$ and the isotopic ratio $d^{13}[CO_2]$ between the two natural isotopes $^{12}CO_2$ and $^{13}CO_2$ in this flux, which are used as tracers enabling the monitoring of the production and transport phenomena. In the time evolution of $F_{CO2}$ and $d^{13}[CO_2]$, significant intra-hour fluctuations are observed, which cannot be explained by a solely diffusive transport of the $CO_2$ in the soil. It is conjectured that these fluctuations are induced by the atmospheric disturbance (i.e. wind) triggering convective transport in the porous soil.

Use of COMSOL Multiphysics®:
This work deals with the modeling of the mass transport of $^{12}CO_2$ and $^{13}CO_2$ in a porous forest soil. It is focused on the analysis of the influence of the pressure fluctuation p at the soil surface, which induces a gas flow in the soil modelled by Darcy's law.
The equations for the transport of the $^{12}CO_2$ and the $^{13}CO_2$ are derived from mass balances on an infinitesimal element of the soil, considering a one-dimensional process and that the diffusion is coupled to the convective transport induced by the gas flow.The source terms describe the $^{12}CO_2$ and $^{13}CO_2$ production rate by the micro-organisms and roots living in the soil.
Two user-defined sets of equations are implemented in General Form using the PDE interface on a one-dimensional domain representing the soil.

Results:

In Figure 1, the simulated time evolutions $F_{CO2}$ and $d^{13}[CO_2]$ involving only the diffusion is compared to their evolutions when a sinusoidal pressure fluctuation is applied at the soil surface (25 Pa of amplitude and 65 s of period). It is clearly observed that it induces fluctuation of $F_{CO2}$ and $d^{13}[CO_2]$ up to 5%. A further analysis shows surprisingly that these flux fluctuations are not directly due to the convective flux. The convective flux actually disturbs the concentration profiles in the soil which induces fluctuation of the diffusive flux. It is besides observed that the diffusive and the convective fluxes are out of phase.

Conclusion:

In this work, the dynamics of the transport of two isotopes of $CO_2$ in a porous forest soil have been numerically studied, coupling diffusion with convection and considering a periodic pressure fluctuation at the soil surface. It is shown that atmospheric disturbances may affect significantly the time evolution of $F_{CO2}$ and $d^{13}[CO_2]$ by an indirect effect of the induced air flow in the soil.

# Figures used in the abstract

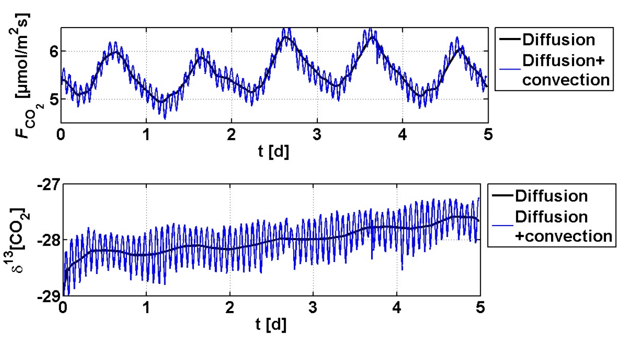


**Figure 1**: Time evolution (in day) of total flux and isotopic ratio of CO2 leaving the soil.