Geophysical Research Abstracts,
Vol. 11, EGU2009-5555-2, 2009
EGU General Assembly 2009

Modelling soil CO_2 diffusion to investigate the effect of non-steady-state on isotopic composition of respired CO_2

U. Gamnitzer (1), A.B. Moyes (2), D.R. Bowling (2), and H. Schnyder (1)

(1) Technische Universität München, Lehrstuhl für Grünlandlehre, Freising-Weihenstephan, Germany, (2) University of Utah, Department of Biology, Salt Lake City, Utah, USA

In the steady-state, the carbon isotopic composition of the soil CO_2 efflux is determined by the respiratory CO_2 production in the soil. But in reality steady-state conditions are rare. Non-steady-state can be introduced either naturally, for example by changes in photosynthetic discrimination due to changes in environmental parameters, or artificially, for example by changing $\delta^{13}C$ of CO_2 in air during a labelling experiment. This complicates the experimental determination of $\delta^{13}C$ of respired CO_2. To quantitatively assess the impact of such changes, we used a one-dimensional iterative diffusion model to calculate the depth profile of CO_2 concentration in soil air as well as its isotopic composition by considering $^{12}CO_2$ and $^{13}CO_2$ as separate diffusing gases. Model predictions were confirmed by observations in two different soil depths.

The model was adapted to allow simulation of chamber-based measurements of non-steady-state effects on the apparent isotopic composition of respiration. These are compared with a dataset from a $^{13}CO_2$ labelling experiment in a grassland ecosystem, where the tracer was observed in total ecosystem respired CO_2 during nighttime. $\delta^{13}C$ of ecosystem respiration, measured with closed static chambers, differed significantly from steady-state measurements using open dynamic chambers. Translated to the fraction of labelled carbon in respired CO_2, the closed static chamber measurements suggested a much larger fraction of tracer in respired CO_2 (70-80% after two weeks of labelling) than the open dynamic chamber measurements (40-50%). The simulations demonstrated that the closed chamber measurements were biased due to non-steady-state effects. Consideration of storage of labelling CO_2 in the soil gas pores during the preceeding labelling period caused a bias of the respiratory signal in the observed direction, but could not explain the magnitude of the bias. When CO_2 dissolved in soil water was also included in the simulation, the order of magnitude of bias of the closed static chamber measurements was also explained.