Trace gas exchange at the forest floor

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In our contribution we focus surface fluxes of the reactive trace gases NO, NO_2, and O_3 at the forest floor, using a flux gradient approach which specifically takes transportation times of the reactants into account.

While in the first meter above the forest soil, vertical concentration gradients can be measured quite easily, the determination of v_{tr} (the bulk (turbulent) transfer velocity; a measure for transport efficiency) requires unconventional approaches. We estimate v_{tr} from measurements of a chemically inert tracer, namely the radioactive noble gas radon (Rn). The vertical distribution and the decay constant (0.0125 s^{-1}) of the short-lived isotope ^{220}Rn ($t_{1/2}$= 55.6 s) are employed to calculate transportation times and corresponding bulk transfer velocities. Combined measurements of vertical concentration differences and soil surface fluxes by static chambers of the long-lived isotope ^{222}Rn ($t_{1/2}$= 3.81 d) result in bulk (turbulent) diffusion coefficients. Once the bulk turbulent diffusion coefficient (directly related to the bulk transfer velocity) for the near-surface gas transport at hand, it is applied to vertical concentration differences of NO, NO_2, and O_3 in order to infer corresponding surface fluxes.

Results from these approaches obtained during field experiments in a Bavarian spruce forest at the Weidenbrunnen/Fichtelgebirge (50.142˚N 11.867˚E, 780 m a.s.l.) in September 2007 and July 2008 are presented. Mean bulk transfer velocities in the first 30 centimetres of the trunk space ranged between 0.003 m s^{-1} and 0.016 m s^{-1}, equivalent to bulk turbulent diffusion coefficients of 0.9 x $10^4 m^2$ s^{-1} up to 4.5 x 10^{-3} m^2 s^{-1}.

We developed a numerical algorithm to consider fast (photo-)chemical reactions of the NO-NO_2-O_3 triad during the turbulent transport within the first meter about the forest floor. By this we corrected surface fluxes of NO, NO_2 and O_3 for the vertical flux divergence caused by chemical reactions. Finally, surface fluxes of NO, NO_2 and O_3 are compared to simultaneously performed direct surface flux measurements by dynamic soil chambers and eddy covariance techniques. Even under very stable meteorological conditions, when turbulence is so small (u_* < 0.08 m s^{-1}), that direct common methods (e.g. eddy covariance) are no longer applicable, the presented approaches can be used to characterise near-surface exchange of non-reactive and reactive trace gases.