A modeling approach of the relationship between nitrous oxide fluxes from soils and the water-filled pore space

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INRA, UR0272, UR Science du Sol, F-45075 Orléans, France

N_2O fluxes can increase largely due to small increase of the soil water-filled pore space (WFPS). In models, the relationship between N_2O fluxes and the WFPS is often described as a continuous exponential curve starting at a WFPS of about 0.62. However, some laboratory and field measurements have evidenced that this relationship could rather be described as Gaussian. To improve our knowledge of this crucial curve for N_2O flux modeling, we have developed a laboratory experiment where the wetting and drying dynamics of undisturbed soil cylinders were strictly controlled during N_2O flux measurements. We observed that N_2O flux peaks could occur during the wetting phase, but more surprisingly we also observed brief and intense peaks during the drying phase. We then hypothesized (1) that N_2O was produced and entrapped during the wetting phase, and was emitted from gas pockets and soil solution during the drying phase and, (2) that the addition of a gas transport and a gas-liquid equilibrium modules to an empirical biogeochemical model of N_2O emissions could allow the description of the brief peaks observed during soil drying. We build such a model. It was first tested with the experimental data. We also studied its sensitivity to the WFPS parameter. We generated 200 realizations of hydric conditions and bulk densities to estimate the soil gas diffusivity. WFPS was set to be constant during the 7 simulated days. Simulated N_2O fluxes plotted against WFPS appeared to be bell-shaped whatever the simulation time, combining the effects of the low N_2O production for WFPS<0.62, and the slow gas diffusion for WFPS>0.9. The WFPS generating the maximum simulated N_2O fluxes shifted with time, from 0.76 after 12 h, to 0.79 after 168 h, because of an increase over time of the gas concentration gradient between the soil surface and the atmosphere. The study highlighted the role of diffusional processes in soil N_2O emissions and the importance to take them into account in N_2O modeling.