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Relationship between gaseous N dynamics and the hydraulic state of hierarchically structured soils

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The inherent spatial heterogeneity of soil generates spatially distributed micro-sites with different local N gas (NO, N_2O, N_2) production and release rates. Moreover, local micro-site conditions and the pathways between them depend on soil moisture which itself is highly dynamic close to the soil surface. These relationships need to be taken into account for a quantitative understanding of soil denitrification and associated N gas dynamics. Soil structure has been recognized as a key factor to understand the high spatial variability of N gas emissions. In particular gaseous N release from soils depends on: i) the total denitrification rate, which is related to the spatial extent and distribution of anaerobic sites and ii) the probability of N_2O to escape from the soil without being further reduced to N_2. This impact of soil structure is typically ignored in studies with soil slurries or repacked soil. In this project we run well-defined mesocosm experiments on N gas dynamics with hierarchically structured, artificial soils in which the spatial distribution of substrate and denitrifiers is known exactly. Sintered, porous glass pellets are inoculated with strains of Paracoccus denitrificans and/or Agrobacterium tumefaciens and amended with nutrient solution. These pellets are embedded in coarse-grained sand within gas-tight columns under O_2/He atmosphere. The pellets are either places in layers or randomly to create different patterns of N gas production sites and diffusion pathways. Denitrification occurs in the anaerobic centers of the porous pellets, while the partially saturated sand matrix controls the diffusive transport of N gases towards the headspace, where all relevant gas concentrations are monitored with gas chromatography. Water saturations are adjusted such that the diffusive pathways are either fully continuous or partially discontinuous. Preliminary results indicate that the water content exert a major control on the magnitude of denitrification, whereas the onset and dynamics are mainly controlled by the position of the substrate and the denitrifiers.