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Modulation of gas fluxes at the soil-atmosphere interface due to coupled physical, chemical and biological effects

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Following an underground nuclear explosion, emission of radioactive gases to the atmosphere is controlled by properties of the geological media and the applied pressures and temperatures. These conditions are highly variable in space and time, leading to modulations of gas fluxes at the soil-atmosphere interface that must be understood for proper detection of nuclear events both through the IMS and during OSI. We focused on the soil system, characterized by variable water content and plant growth. We developed an improved set-up to conduct gaseous tracer experiments under controlled conditions mimicking natural ones. Although a constant tracer gas flux was applied at the base of a soil column, the measured gas fluxes at the surface varied by ca. +300% to -100% within hours to days compared to the injected one. This is due to changes in the water distribution in the soil, controlled by multiple effects of physical, chemical and biological origins. Modulations of the radioxenon or argon-37 fluxes to the atmosphere must then be taken into account for better determinations, especially when these fluxes are integrated in space and time. This can be predicted by numerical modeling knowing the environmental conditions.

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