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Parameterisation of radon diffusivity and exhalation rate from soils – limitations and its applicability to other trace gases

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Quantitative understanding of the processes governing radon production and transport in soils and its exhalation rate into the atmospheric boundary layer are essential if we want to use this radioactive noble gas to assess above- and below-ground transport processes. While production of radon in soils is mainly governed by static soil properties such as texture and uranium content, the dominant parameter modulating its exhalation rate is volumetric soil moisture. Here we present an improved process-based high-resolution radon flux map for Europe, using up-to-date soil property maps, including updated uranium activity concentration data from the European Atlas of Natural Radiation. Daily radon exhalation is calculated based on high-resolution soil moisture estimates from the ERA5 and the GLDAS Noah land surface models. Depending on the soil moisture model used, estimated radon fluxes show differences as large as a factor of two, but modelled soil moisture and corresponding modelled radon fluxes also differ from observations. This highlights the importance of accurate representative soil moisture observations for model validation. Although the fluxes of biogeochemical reactive trace gases at the soil-atmosphere interface are also driven by other variable parameters, such as temperature or microbial activity, their net fluxes can often also be limited by effective diffusivity in the upper soil layers, and thus by soil moisture. Estimating variability and uncertainty of biogeochemical active trace gas fluxes such as methane or hydrogen on the regional or continental scale could therefore benefit from experience with the noble gas radon.