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European 222Rn flux map for atmospheric tracer applications

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Observations of atmospheric 222Rn are widely used to evaluate climate models simulating transport, transformation and removal of gases and aerosols. Used in inverse mode, these models can provide information on location, extent and strength of sources and sinks of greenhouse gases based on the measurement of changes in their atmospheric concentrations. Currently, the effective use of 222Rn in this context is limited by the accuracy of the 222Rn source function. We developed a 222Rn flux map for Europe, based on measurements of terrestrial gamma dose rate, a widely measured proxy, which has been found to be the most closely related. The model predicts regional averages of 222Rn flux. The correlation between 222Rn flux and gamma dose rate was established from measurements of both parameters in Switzerland, Germany and Scotland. A verification at independent locations in Finland (Helsinki and polar circle regions) and Hungary showed that measured regional means differed by a factor of up to three. Still, predicted means were within the error margin of the respective measured mean. The predicted mean 222Rn flux for Europe is 0.55 atom cm-2 s-1, which is substantially smaller than the commonly assumed 1 atom cm-2 s-1. Half of the area has 222Rn fluxes between 0.4 and 0.7 atom cm-2 s-1. Predicted seasonal variation was particularly pronounced in the northern regions with an amplitude of about +/- 25 %. Large emissions were predicted for the Iberian Peninsula, particularly low emissions for northern parts of Scandinavia, much of the coastal regions and Greece. In this paper, we present the differences in modelled atmospheric 222Rn concentrations for several stations in Europe, brought about by our improved 222Rn flux term compared to the commonly used uniform flux term of 1 atom cm-2 s-1.