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Advances in the European Indoor Radon Map, towards a European Indoor Radon Dose Map

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The European Indoor Radon Map (EIRM) displays the annual average indoor radon concentration measured on ground floor of residential dwellings by using existing data provided by national authorities. Authorities provide summary statistics (number of measurements, arithmetic mean and standard deviation, AM and SD of ln-transformed data, median, minimum, maximum) aggregated over grid cells of 10 km x 10 km. Results are collected, checked for errors and mapped by the Joint Research Centre (JRC) of the European Commission. A digital version of the map is freely available from the JRC website (https://remon.jrc.ec.europa.eu/About/Atlas-of-Natural-Radiation). After 12 years, data have been collected from more than 1.2 million individual dwellings, distributed over more than 28,000 grid cells.

A map which displays doses resulting from indoor radon would be at least equally relevant. The main challenges consist in the fact there are still a large number of grid cells with no or very few indoor radon measurements, and that most people, in particular in cities, do not live in ground-floor dwellings; as radon concentration generally decreases with increasing floor level, a dose map based solely on ground floor data would lead to overestimation of dose.

In this study we present the advances in the EIRM and the actual stage of the European Atlas of Natural Radiation (digital version and publication). The approach for estimating an indoor radon concentration in the grids where no or few data are available is also presented. Four interpolation techniques have been tested: two of them (i.e. Inverse Distance Weighted; and Ordinary Kriging) use solely the indoor radon concentration measurements; whereas the other two (i.e. Collocated Cokriging with Uranium as secondary variable, and Regression Kriging with topsoil geochemistry and bedrock geology as secondary variables) also take into account geogenic factors.

A model-based dose estimation is finally discussed. First, we assume that on average, the frequency of dwellings located on higher floor levels is higher in cities than in the countryside. As proxy to decide whether one particular cell of the indoor Rn database (individual measurements are not available for data protection reasons) belongs to a city or to countryside, we use population density in that cell, which is available Europe-wide. Second, we establish a model of frequency of floor levels, in dependence of population density, from regional datasets which are population-representative. Third, we apply "floor correction" to each cell in accordance with an empirical model which relates radon concentration to floor level. Thus we get a floor-corrected version of the indoor radon map. Finally, we use dose conversion factors to estimate the dose.

The procedure must be tested for consistency and plausibility by common statistical methods. However, we do not attempt to produce an authoritative European indoor radon dose map. After all, it may be that the correction models themselves have an underlying regional trend, possibly due to climatic or cultural factors. This can only be decided by applying the procedure to different regional datasets.