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Mapping the outdoor effective dose: the case study of the Umbria region (Italy)

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The absorbed dose rate due to natural radioactivity arises from terrestrial and cosmic sources, both contributing to the individual effective dose rate per fraction of time spent outdoor. Rocks and soils are the main reservoirs of terrestrial gamma-emitting radionuclides (e.g. ^{40}K and radioisotopes of the ^{232}Th and ^{238}U chains) while high-energy particles originated from astrophysical phenomena produce a cascade of nuclear interactions which contributes to cosmic radiation decreasing in intensity with the atmosphere depth. Following the UNSCEAR 2008 report, the average exposure of the world population to the different natural radioactivity sources corresponds to about 2420 μSv/yr and the external effective dose of terrestrial and cosmic origin is 870 μSv/yr.

The Umbria region (Italy), with its high variability of sedimentary and igneous rocks (e.g. limestone, sandstone, volcanic tuff) and a population of about 880000 inhabitants well distributed between 100 m and 1000 m a.s.l., represents the ideal case for mapping the effective dose from natural sources in a multifaceted environment. The outdoor effective dose rate from terrestrial radionuclides is studied by analysing 7439 gamma spectra measuring rock and soil samples in laboratory and carrying out about 20 hours of airborne radiometric surveys. Collocated CoKriging is used for the spatial interpolation of the sparse data, adopting a high-resolution geological map as ancillary information. The obtained numerical map is integrated with the cosmic radiation effective dose rate calculated considering the effects of altitude, latitude and the solar magnetic activity cycle. The resulting map of the outdoor effective dose rate shows a median value of 632 mSv/yr and only 3% of the territory is characterized by values higher than 814 mSv/yr.